Evaluation of the Membrane Filtration and Most Probable Number Techniques Based on Replicate Analyses of Three Raw Water Sources and Sixteen Pure Coliform Cultures

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EVALUATION OF THE MEMBRANE FILTRATION AND MOST PROBABLE NUMBER TECHNIQUES BASED ON REPLICATE ANALYSES OF THREE RAW WATER SOURCES AND SIXTEEN PURE COLIFORM CULTURES

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ABSTRACT

Smando, R. 1983. Evaluation of the membrane filtration and most probable number techniques based on replicate analyses of three raw water sources and sixteen pure coliform cultures. Can. Manuscr. Rep. Fish. Aquat. Sci. 1687: v + 43 p.

A number of comparative Membrane Filtration (MF) and Most Probable Number (MPN) replicate analyses were performed on raw and impure waters obtained from the Red and Assiniboine Rivers and from the South End Pollution Control Centre - all sampling sites located in Winnipeg, Manitoba. There were significant statistical differences between the MF and MPN techniques in a number of the individual replicate experimental trials but a consideration of the overall results showed that when the geometric mean was used for the averaging process there was no overall statistical difference between the two methods; however, the MF procedure appeared to exceed the MPN methodology in the precision and accuracy of replicate counts.

Two hundred identifications of predominant coliforms appearing on the membrane filters and MPN tubes showed that for the Red River sampling 67% were Klebsiella pneumoniae, 20% Escherichia coli, and the remainder Enterobacter cloacae, Enterobacter agglomerans and Aeromonas hydrophila, the last organism a non-coliform which usually could be eliminated from the enumeration procedure with the use of a portable fluorescent light. Aeromonas hydrophila colonies on the membrane exhibit a pinpoint sheen when illuminated with a fluorescent light. True coliform colonies in contrast exhibit a more solid sheen on the membrane.

From the two hundred organisms isolated in both the MF and MPN techniques employed in the analysis of sewage samples, the isolates were identified as Escherichia coli (30%), Klebsiella pneumoniae (24%), Aeromonas hydrophila (16%), Enterobacter cloacae (12%), Enterobacter agglomerans (10%) and Citrobacter freundii (8%).

Using some of the strains identified from the foregoing Red River and sewage samples a pure culture replicate analytical study was performed in generally replicates of eight for both the MF and MPN methodology and the three reference plating agars - standard plate count (SPC), MacConkey, and Eosin Methylene Blue (EMB) agars. The MF procedure correlated very closely with both the SPC and EMB agars indicating no significant statistical differences between these three methods. On the other hand, there was a significant statistical difference exist between the MPN results and the above plating agars - the MPN methodology falling on the extreme high side, outside the 95% confidence range and the MacConkey agar falling on the extreme low side also outside the 95% confidence range and could not be used as an absolute reference agar. Lower counts obtained in the MacConkey agar were attributed to the inhibition of the coliform group of organisms by the crystal violet present in the medium.

The overall conclusions reached in this study based on the statistical analysis presented, showed without doubt, the MF procedure to be a more precise and accurate methodology over the MPN technique for the enumeration of coliforms either in badly contaminated water or in pure cultures. The MF methodology should thus be the method of choice for the analyses of water by a regulatory agency - especially when it can be used so conveniently in the field where problems can be corrected within 18-24 hours, on site of a fishery operation.

Key words: water filtration; water analysis (biological); microbiology; bacterial counters.

RESUME

Smando, R. 1983. Evaluation of the membrane filtration and most probable number techniques based on replicate analyses of three raw water sources and sixteen pure coliform cultures. Can. Manuscr. Rep. Fish. Aquat. Sci. 1687: v + 43 p.

On a effectué plusieurs analyses répétées comparatives par filtration sur membrane (FM) et par la technique du nombre le plus probable (NPP) sur des échantillons d'eaux brutes et polluées prélevés dans les rivières Red et Assiniboine et au South End Pollution Control Centre. Tous les points d'échantillonnage étaient situées à Winnipeg, au Manitoba. Les résultats obtenus avec les deux techniques différaient de façon statistiquement significative pour plusieurs analyses individuelles répétées, mais aucune différence significative entre ces techniques n'a été notée pour l'ensemble des résultats lorsqu'on utilisait la moyenne géométrique. La précision et l'exactitude des dénombrements répétés semblent cependant supérieures avec la technique FM comparativement à la technique NPP.

L'identification de deux cents des principaux coliformes se trouvant sur les membranes filtrantes et dans les tubes NPP ont donné les résultats suivants pour les eaux de la Red River: 67% de Klebsiella pneumoniae, 20% de Escherichia coli, le reste étant représenté par Enterobacter cloacae, Enterobacter agglomerans et Aeromonas hydrophila. Ce dernier organisme n'est pas un coliforme et l'on peut généralement éviter de l'inclure dans la numération en utilisant une lampe fluorescente portative. Les colonies d'A. hydrophila sur les membranes filtrantes présentent un reflet ponctuel sous la lumière fluorescente, tandis que les colonies des coliformes vrais présentent un reflet plus uniforme.

Les deux cents organismes isolés par techniques MF et NPP dans des échantillons d'eaux usées se répartissaient comme suit: Escherichia coli (30%), Klebsiella pneumoniae (24%), Aeromonas hydrophila (16%), Enterobacter cloacae (12%), Enterobacter agglomerans (10%) et Citrobacter freundii (8%).

En utilisant certaines des souches identifiées dans les échantillons d'eaux de la Red River et d'eaux usées ci-dessus, on a effectué une étude analytique en cultures pures. Les analyses individuelles ont généralement été répétées huit fois avec les techniques MF et NPP et les cultures sur géloses standard à savoir: la numération standard sur plaque (NSP) et la numération sur géloses MacConkey et à l'éosine et bleu de méthylène (EBM). Les résultats obtenus par technique MF présentaient une trés bonne corrélation avec ceux obtenus sur géloses NSP et EBM indiquant ainsi l'absence de différences statistiquement significatives entre ces trois techniques. Les résultats obtenus par la technique NPP et les trois géloses mentionnées plus haut différaient cependant de façon significative. La technique NPP n'était pas fiable pour les concentrations trés élevées, les résultats ne se situant pas dans l'intervalle de confiance de 95%; la gélose MacConkey n'était pas fiable pour les très faibles concentrations, ses résultats se situant aussi à l'extérieur de l'intervalle des 95%. Cette gélose ne pouvait donc servir de gélose de référence absolue. Les faibles numérations sur gélose MacConkey ont été attribuées à une inhibition des coliformes par le violet cristal présent dans ce milieu.

Les conclusions de cette étude, basées sur l'analyse statistique présentée, indiquent de façon certaine que la technique MF est beaucoup plus précise et exacte que la technique NPP pour la numération des coliformes, que ce soit en eaux fortement contaminées ou en vultures pures. Les organismes de réglementation devraient donc utiliser de préférence la technique MF pour l'analyse des eaux, surtout lorsqu'elle se prête si facilement à une utilisation sur le terrain où des corrections peuvent être apportées en l'espace de 18 à 24 heures, par exemple sur les lieux mêmes d'une pêche.

Mots-clés: filtration de l'eau; analyse de l'eau (biologique); microbiologie; compteurs bactériens.

INTRODUCTION

The direct testing for enteric pathogenic organisms in water presents a number of problems which are beyond the scope of the normal routine procedures used by most water laboratories. However, the Coliform group of organisms which are found in the intestinal tract of man and animals is of primary interest to the water microbiologist since their presence in water is indicative of a potential health hazard due to the possible presence of pathogenic organisms responsible for such diseases as typhoid fever, dysentery, and cholera.

After the Phelps Index methodology (31), two major and basic methods have evolved for the determination of Coliforms in water and are presently accepted procedures in "Standard Methods for the Examination of Water and Wastewater" (1) as well as in other authoritative water testing source manuals. These are the MPN (most probable number) technique and the MF (membrane filtration) methodology.

For years the classical test for the examination of Coliform density in water supplies and wastewater disposal systems has been the tube fermentation system (MPN). However, over the past quarter century an increasing number of laboratories have been adopting the MF technique, which offers an alternative and simpler approach than the somewhat cumbersome tube procedure. The application of the MPN test takes advantage of the ability of the Coliform group of organisms to ferment lactose at 35°C in an appropriate medium producing CO_2 gas in 48 hours whereas the MF technique employs a 0.45 micrometer pore size, membrane filter as a bacterial collecting device. By the capillary action of its pores, the membrane filter draws the selective medium around each separate Coliform organism entrapped in the membrane filter which develops into visible growth on the membrane surface. When an individual Coliform organism on the surface of a membrane filter ferments lactose, it grows into a separate discrete colony producing an intermediate metabolic compound, an aldehyde, which is identified by the appearance of a metallic sheen on the surface of the colony as a result of an aldehyde complex formed from an interaction with the basic fuchsin and sodium sulfite within the Coliform medium (2).

The MPN procedure yields a statistical estimate of the most probable number of organisms in a given amount of water. This number is determined by the number of positive and negative fermentation tube reactions occuring in the three-dilution multiple tube test. The 95% confidence limit for the five-tube, three dilution MPN test, ranges between 31 and 289% of the true bacterial density of the water sample (3,5,7). Thus, if a single water sample is analyzed 100 times 95 of these MPN results will be in this range and 5% higher or lower than this range. In interpreting MPN data an investigator should be aware of the assumptions of applying this technique which is as follows (4):

1. Organisms in the sample are distributed at random.
2. Organisms exist independently of each other.
3. A single organism is sufficient to give a positive test.

The above, of course is not always true since organisms may not be distributed at random (1), organisms do not exist independently of each other due to synergistic or antagonistic activities of the same, leading to false positive or false negative results (5,7), and a single organism may not yield a positive test (11). As stated by Geldreich et al. (5) "False positive results in the multiple tube test may originate from several sources including anaerobic spore formers of the Clostridium welchii type, spore-bearing aerobic forms related to Bacillus subtilis, and to the symbiotic action of two different organisms neither of which alone can ferment lactose." Other influences may be predatory protozoa, bacteriophage etc. Thomas et al. (6) stated the following: "The false positives (MPN methodology) are eliminated by the completed test which is not usually performed in the routine water examination. In certain waters, the results may be lower by as much as a factor of 10, following elimination of false positives. Therefore, even though the MPN method has been adopted and universally used, it is subject to certain inaccuracies and should be considered as an index of the number of coliform organisms present. In addition to the above biological factors which contribute to its inaccuracy, there is a purely mathematical source of inaccuracy, which is inherent in the MPN estimate of coliform organism density." This estimate, like many other maximum-likelihood estimates used in mathematical statistics, is biased. The **arithmetic** mean of a large number of replicates, in general overestimates the true density by 27% in the 5:5:5 series and 43% in the 3:3:3 series (4,10,11).

The above shows the limitations and problems encountered with MPN estimates. However, the MF technique used by a number of water laboratories presents no panacea since it also has certain limitations in its applicability. The counting of sheen colonies on the filter, for example, initially creates problems for the technician even if he/she is experienced in the use of the membrane technique. Dilution procedures and/or filtration volumes to be used in the MF procedure may also present experimental difficulties especially with water samples containing unknown Coliform counts. "Occasionally Coliform organisms may fail to produce colonies with metallic sheen, or other colonies will develop as sheen colonies but in fact are non-Coliform bacteria" (5). Moisture in the colonies will at times present a glistening appearance (usually eliminated by allowing plates to sit at room temperature for an hour or so before counting) which can be misinterpreted as "sheen" colonies, or the colonies may become crowded with other types of colonies preventing good Coliform development. These false sheen reactions are the result of interferring substances in the water (8,9) and atypical strain responses to growth rate or fermentation velocity. However, "these occur in both the multiple tube procedure and the MF procedure" (5). In fact the MPN procedure is more sensitive to

antagonisms in a water sample since in the MF procedure the soluble antagonists are filtered out with the filtrate and others exist independently of each other on the membrane surface. "Generally, false negative results are a rare occurence when using the MF procedure" (7). Also, false positive with the MF technique are generally rare (7).

In the study undertaken by Geldreich et al (5) on 4,900 Endo sheen colonies from 1,200 MF filtrations of 14 municipal raw water supplies located in various geographical areas of the U.S., the results indicated that 427 (8.7%) of these colonies were "false positive" strains that failed to produce gas in brilliant green bile after initial fermentation in lactose. However one does not expect a 100% correlation between the two methods. What is important here is that both methods have the same sanitary significance (1). The organisms involved were various strains of Klebsiella, Bacillus, and Erwinia. Slow lactose fermentation (gas in 48-96 h) was the result of species of Escherichia, Aerobacter, Paracolobactrum, Vibrio, Klebsiella and Erwinia - which may be a natural characteristic of these strains, or perhaps caused from interferring substances in the water. Paracolobactrum species occurred as the most frequent false positive, producing sheen as a result of the partial breakdown of lactose (5). Certain strains of Serratia marcescens may also at times produce a metallic sheen colony (7). In the present work, the organism Aeromonas hydrophila was somewhat troublesome due to the production of a pinpoint sheen in the Endo Les medium employed in this study.

Usually the Coliform density estimates obtained using the MF technique are generally less than those obtained by the standard MPN method. The difference in density estimates is partly, but not entirely attributable to the mathematical bias of the MPN (4,5). However, in some low density waters the MF procedures have been found to yield higher recoveries than the MPN methods. High relative recovery in these cases may be attributed in part to the preference shown by many varieties of Escherichia and Aerobacter species for growth on moist surfaces rather than in the free floating state (5).

Other problems associated with the MF procedure are turbid waters, algae blooms, high counts of non Coliform bacteria, attenuation (also affects the MPN procedure) of some Coliforms as a result of zinc and copper sulfate (8,9) plus other interferring substances in industrial wastes.

There are certain technical considerations that deserve mention in the MF procedure. The membrane filters should be standardized (0.45 micron - pore size), they should contain no inhibitory substances in the filter paper itself or in the ink used to delineate the grid lines, the medium should be the same as that presented in standard methods (1) and its quality assured. A fluorescent lamp should be used to facilitate counting of colonies, and the training of technicians is necessary so that only Coliform sheen colonies are counted and no false positive colonies are included in the final counts such as the smaller pinpoint colonies one occasionally encounters.

As far as the costs of the two procedures are concerned the minimum cost per test employing the MPN technique is approximately $0.83 versus $0.45 for the MF procedure (7). An additional advantage of the MF over the MPN methodologies is the fact that a permanent record of the sample counts can be retained for re-checks or for teaching purposes etc.

Also, the MF methodology can be performed in the field where water samples are immediately filtered and the membranes incubated in the chamber provided by the MF field kit (Millipore Corp.).

The failure to be aware of the broad confidence limits inherent in the MPN calculations has at times led to a conclusion from the MPN-MF comparisons that the MF does not detect all of the Coliform population present in a given water sample. Important is the fact that the MF procedure is based on an actual count on Coliform bacteria whereas the MPN methodology yields only a statistical estimate of the most probable number of organisms in a given amount of water (10, 11).

The MF technique proved by various investigators to be a method equally effective as the MPN procedure for the estimation of Coliforms in water (1,2,5,6,12,13,14). In fact various evaluations of the MPN-MF reported in the literature leave no doubt as to the excellent precision and accuracy of the membrane filter procedure for most water supplies (11,15,16,17,18, 19,20,22, 23). Since publication of the 11th edition of Standard Methods of Water and Wastewater, widespread use of the technique has confirmed its value, especially its high degree of reproducibility, the possibility of testing relatively larger volumes and a greater number of samples, and its ability to yield definite results more rapidly than the standard tube procedure. The MF filter technique has shown to be extremely useful in many aspects of Coliform analyses, however, it may still be desirable to conduct parallel tests in order to demonstrate applicability and to familiarize the worker with the procedures involved.

Although there has been much work done on water analyses that shows excellent precision and reproducibility of the MF procedure, this present study was undertaken to show that this in fact is true and to satisfy ourselves that the MF procedure is a reliable technique that could be extremely useful especially in the field. Field problems could thus be corrected on almost an immediate basis and on site in 18-24 h that are required for the development of visible Coliform sheen colonies for counting. On the other hand the MPN procedure undertaken in a home-based laboratory demands that field personnel return to the lab the same day the water samples are collected since our Standard Methods Manual (24) states that the holding time should not exceed 6 h for impure waters and for all sea samples, and should not exceed 12 hours in any case. The interpretation of results for the MPN technique takes 96 hours in comparison

to the 18-24 h period required in the MF procedure. Also, since the MPN procedure is not performed in the field, but in the home-based laboratory, an additional trip out to the field would be necessary to correct the problem(s) that may arise. This is costly in terms of man hours and travelling expenses, especially in remote areas that are only accessible by either poor roads or aircraft. In the meantime, while these additional trips are being planned, a problem plant will be using contaminated water in its fishery operations. However, by using the MF field kit, the problem would have long been corrected on site in the first initial field trip.

MATERIALS AND METHODS

WATER SAMPLE SOURCES

Water samples for this study were collected from basically four sources located in the City of Winnipeg, Manitoba - the Red River, Assiniboine River and from the primary and final effluents in the South End Pollution Control Centre, Department of Water Works, Wastes and Disposal Division (SEPCC) located just south of Winnipeg's south perimeter highway.

Samples obtained from the Red River were taken from the ends of two docks located at the bottom of the Winnipeg Canoe Club. The water samples obtained from the Assiniboine River were also taken from the ends of two docks located at the Maryland bridge. Upstream samples are distinguished from downstream samples by a distance of approximately 100 yards (the distance between the docks) located at these sampling sites. The actual locations of the sampling sites are not shown here as these waters were used only as sources of bacterial populations for both the MF and MPN estimations. These sources were chosen since they would contain a limitless number of antagonistic components which might possibly interfere with either the MF or MPN methodology. These sampling sources would also contain a variety of Coliform organisms, a number of which were isolated and purified in this study, and used for the pure culture experimentations to be described later.

METHODOLOGY OF OBTAINING WATER SAMPLES

All sampling depths were limited to approximately six inches below the surface of the water source. All samples were obtained by initially inverting the sterile sample bottle below the surface of the water source to a depth of six inches, the sample bottle reverted upright, and moved forward against the current in the case of the Red and Assiniboine Rivers, and just moved forward slightly in obtaining samples from still water sources, i.e. the South End Pollution Control Centre. The sample bottles were then filled to approximately three-quarters of their maximum capacity to allow room for manual shaking of samples 25 times just prior to analysis. Rubber gloves were used to obtain all samples.

DILUTION OF WATER SAMPLES

Water samples were diluted so that aliquots of 1.0, 3.0, 5.0 and 20, 50, 100 mL could be used for membrane filtrations and 10, 1.0 and 0.1 mL for MPN evaluations. The sample dilutions that were used for both MF and MPN analyses were either kept continuously stirring on ice with a magnetic stirring bar while aliquots were being removed for analysis, or were manually shaken via 25 up and down movements through an arc of 1.0 foot - just prior to usage for filtrations or MPN tube inoculations (24).

MEMBRANE FILTRATIONS

Generally, aliquots of sample dilutions filtered through the membrane filters were followed by two thorough swirling rinses of the funnel assembly via two 10 mL aliquots of 0.1% peptone buffer. When less than 10 mL was used for membrane filtrations this aliquot was added to 90 mL of sterile diluent and the entire contents filtered through the membrane. The filtration funnel assembly used for all filtrations was that included in the millipore "Portable Water Analysis Kit". This kit was obtained from Millipore Corporations, Ashby Road, Bedford, Massachusetts 01731, under Fed. stock No. 6665-682-4765. To speed up analytical time a vacuum pump, instead of the manual pump supplied with the kit, was used to draw the filtered water through the membranes. The unit was plugged into a 115 volt power outlet and the temperature adjusted to 35°C ± 1.0°C. Temperature fluctuations were monitored for a period of one week before the incubator was used for MF incubations. A Puffer-Hubbard Incubator (35°C ± 1.00°C; model #1-43-2TN) was used for some MF incubations (as indicated in RESULTS) and all MPN incubations. The Puffer-Hubbard incubator is referred to in RESULTS as the large (LARG) incubator.

STERILIZATION OF THE MF FUNNEL ASSEMBLY

The sterilization of the funnel assembly involved squirting the asbestos wick on the filter holder base with methanol. The methanol was ignited, allowed to burn for a few seconds, and the stainless steel flask subsequently placed on top of the funnel assembly and allowed to sit on the same for 15 minutes prior to any filtrations. The incomplete combustion of methanol produces formaldehyde which is a bactericide. To prevent residual formaldehyde from interferring with bacterial growth on the first filtration after sterilization, the funnel assembly was thoroughly rinsed with sterile, 0.1% peptone water before use. Before filtrations of aliquots of sample dilutions a 100 mL aliquot of sterile peptone water was filtered through a membrane and labelled as control. All filtered membranes were rolled (to avoid entrapment of bubbles) on the surface of the Endo Les Agar contained in the small Petri plates designed for this methodology. The filtration of sample dilutions or aliquots of sample dilutions involved the filtration of the most dilute to

the least dilute dilutions. When a number of dilutions of the same sample were filtered through membranes, the funnel assembly was not sterilized between filtrations. When different water sources were being tested the funnel assembly was sterilized between filtrations of these water samples.

MEMBRANE FILTERS

Unless indicated elsewhere, (preliminary study, Tables 1, 2) the membrane filters used for all filtrations were individually wrapped Gelman GN-6, 0.45 mm, GRID, membranes, lot number 2378029. Gelman plastic filter dishes (50 mm x 9 mm) were also used to incubate these membranes on the m Endo Les Agar media used in this study.

MPN METHODOLOGY

All MPN (and MF) results shown in the tables presented in this report are expressed as counts per 100 mL of original sample analyzed.

Except for the last series of experiments involving pure culture work all MPN results are based on using 10, 1.0 and 0.1 mL aliquots in representing the multiple Tube Decimal dilution plantings - in either the 3:3:3 or 5:5:5 MPN series. Since the MPN tables are based on using the 10, 1.0 and 0.1 planting series of tables all final results were obtained by multiplying the results attained in the MPN tables by the dilution used for the inoculation of MPN tubes.

In the pure culture work 1.0 mL of four dilutions were used to inoculate the MPN tubes. To obtain the final results in the pure culture work the same MPN table was used as in foregoing. Using the four dilution method the three dilutions to be employed in determining the MPN index, taking the system of five tubes of each of four dilutions used, as an example, the highest dilution which gives positive results in all five portions tested (no lower dilutions giving any negative results) and the two succeeding higher dilutions were chosen to determine the MPN index (1, p. 925).

BACTERIOLOGICAL MEDIA

Difco Endo Les media (control #642824) was used for supporting the growth of coliforms entrapped on the membrane filters. This medium was used without the suggested 1 1/2 - 2 1/2 h preenrichment step in lauryl tryptose broth. This preenrichment step was avoided for a number of reasons. Discussions with personnel at the Millipore and Gelman Corporations said this step was unnecessary. Discussions with scientific co-workers also said that this extra step was unnecessary for analyzing freshwater samples. Also this preenrichment step would be too cumbersome to use in the field. Early experimentation showed excellent recovery of coliforms without the use of this preenrichment technique. All Endo Les media used for MF incubations was no more than 3 days old from the day it was prepared. The media during this three day period was stored in the dark at 4°C and after 3 days was discarded.

Difco lauryl tryptose broth (LTB) control number 585221 was used for the presumptive MPN coliform test and Difco Brilliant Green Bile, 2.0% (BGB, control numbers 644213, 644881) was used as a confirmatory medium for MPN total coliforms at 35°C.

Both the MF and MPN inoculated media were incubated and evaluated according to Standard Methods for the Examination of Water and Waste Water, (1).

IDENTIFICATION TECHNIQUE

Prior to identification, metallic sheen colonies on the membranes were selected via a wire loop and restreaked for purity on Eosin methylene blue (EMB) and MacConkey's Agar. Separated colonies on these two latter media were then inoculated into nutrient Agar slants where the cultures were maintained and stored until further use. Identification of cultures was made from young (18 h) nutrient agar slants. Sterile wooden applicator sticks were used to scrape off, from the surface of the slants, a visible amount of bacterial growth. This visible mass of growth was then introduced into a test tube containing 5.0 mL of sterile 0.85% saline. The cell suspension was then mixed vigorously prior to use. After mixing this cell suspension, an aliquot of the suspension was taken up into a Pasteur pipette and the vacuals of API 20E (Analytab Products Inc., (25)) strips inoculated. The inoculated strips were incubated at 35°C for 18-24 h and identifications made after the end of this time. Along with the identifications of the metallic sheen producing organisms the same strains were also tested for gas formation in lactose broth for 48 hours followed by BGB (2.0% Bile) for a further 48 hours. Some of the cultures that produced sheen colonies on the MF media and also gas positive in LTB and BGB media were chosen for the pure culture study undertaken in this report.

STATISTICAL ANALYSES

Simultaneously, along with the ANOVA procedure, Duncan's multiple range test (26,27,28, 29) was employed to rank, the geometric means of the data, for each variable and where there was a significant difference between means at the 95% confidence level, the means were arranged in groups to identify the means which were not significantly different from each other. The rankings of the means for each test were summarized and a CHI-square evaluation was conducted to determine if the rankings occurred with theoretically random frequency, or if there were statistically apparent patterns with some means being significantly highest or lowest in rank.

Note: Geometric means had to be exclusively used on all the data presented in this report due to the invariable scattering of the replicate MPN data. The geometric means generally reflect more meaningfully the

actual means residing in the replicate analyses since geometric means tend to compensate more accurately for the outlying high/low count(s) experienced in replicate analyses.

RESULTS

Table 1 shows some preliminary data comparing MPN values (both 5:5:5 and 3:3:3 series) with counts obtained from two leading brands of membrane filters, Gelman and Millipore. A variety of membrane filters from each company were used to determine which membranes had generally the highest recovery rates. One MPN and MF result is expressed for each experimental trial run. All values are expressed as total coliforms per 100 mL sample analyzed.

Table 2 summarizes the data presented in Table 1. Table 2 shows only the corresponding experimental MPN (48 h LTB- 48 h BGB) and MF mean values obtained from samples evaluated in Table 1. Both the 5:5:5 and 3:3:3 MPN values are compared to the MF values obtained using the various membrane filters. There is perhaps an indication that MF values appear to generally correlate fairly well with the MPN data when either m Endo broth or m Endo Les Agar are used to support bacterial growth on the membranes. However, due to availability, consistency of counts, ease of counting metallic sheen colonies, ease of usage, etc., the "GN" Gelman, individually wrapped membrane filters and m Endo Les Agar medium were chosen for the remaining work to follow. Field use of the Portable MF Field Kit by trained personnel would also require the easy usage of individually wrapped membrane filters and a suitable bacteriological medium.

Table 3 (A-G) shows both the 5:5:5 and 3:3:3 MPN estimations (48 h LTB, 48 h BGB) versus the MF methodology of obtaining coliform counts (expressed per 100 mL/sample analyzed). The large and portable incubators (held at 35°C) used to incubate the membrane filters refers to a large immobile Puffer-Hubbard incubator located in the laboratory and the small portable MF Field Kit respectively. The experiments were performed in replicates of three for the MPN data and generally, in replicates of five for the MF data.

Table 3 shows the dates of samplings and analyses (analyses conducted within 4 hours of sampling) conducted on Red River Upstream (RRU), Red River Downstream (RRD), Assiniboine River Upstream (ARU) and Assiniboine River Downstream (ARD) samples. Each replicate experiment is considered as a separate experimental "trial" run. The MPN data are seen to scatter tremendously within the three evaluations carried out per sample while the replicate MF data seem to be more consistent and uniform throughout the replications.

During this study a number of colonies were selected from the membrane filters used in filtering Red River samples - for indentification via API identification strips. Some of these cultures were used for the pure culture work to be described later. Of all the 200 colonies tested, 80% were gas-positive in LTB (48 h) & BGB (48 h) and yielded mainly Klebsiella pneumoniae (67%), Escherichia coli (20%) and the remainder Enterobacter cloacae, Enterobacter agglomerans and Aeromonas hydrophila, (a non-coliform). During the enumeration procedure Aeromonas hydrophila would occassionally be included with the rest of the true coliform organisms. However, the use of a fluorescent light minimizes this error since the Aeromonas strains show more of a pin point sheen under this type of light and can usually be eliminated from the counting procedure. A portable fluorescent light would be required for field use.

Table 4 shows the results of a statistical analysis performed on the data presented in Table 3. An analysis of variance and Duncan's multiple range test were performed separately on each replicate experiment (Table 3A-G) for each sample source. The columns in Table 4, from left to right show the date the sample was obtained and analyzed; the number of replicate analyses performed for each replicate experiment for each of the four variables analyzed per trial i.e. for the 5:5:5, 3:3:3, large (LARG) and portable (PORT) geometrically averaged variables; the respective averaged geometric values of these replicate analyses per experiment; the F values; d.f. values, and the ranking of the four variables according to their geometric mean values into bracketed groups, in descending numerical order, from the highest to successive lowest values i.e. into first, second, third and fourth order. Variables within the same bracket are not significantly different from each other.

Table 4 shows the MPN and MF mean data of 34 individual replicate experiments. Out of these 34 geometrically averaged analytical results the MF results obtained using both and the large and portable incubators appear together in the bracketed groups 34 times, showing a 100% correlation with each other. However, the 5:5:5 and 3:3:3 series do not show this correlation since these two analytical results appear together in the same group only 24 times out of 34 or 70.6% of the time indicating that there was a statistical significant difference between the 5:5:5 and 3:3:3 MPN series in 29.4% of the replicate experiments. The large or portable incubator MF results are associated with the 5:5:5 series 23 out of 34 times or 67.6% of the time, or with the 3:3:3 series 21 out of 34 times or 61.8% of the time showing equal correlation of the MF data with either of the two MPN series.

The large and/or portable incubator MF results are collectively associated with the 5:5:5 and 3:3:3 MPN Series 28 out of 34 times. The results show a 82.4% correlation with both of the MPN series.

Table 5 shows the frequency of occurrence of the 4 variables, 5:5:5, 3:3:3 LARG and PORT incubations in first, second, third, and fourth place in the 34 trials. A CHI square test performed on each variable separately results in increasing values - 1.29 for the 5:5:5 MPN series, 2.00 for the large incubator, 3.18 for

portable incubator, and 4.82 for the 3:3:3 MPN series. This order and these values show that there is no significant difference of the four variables 5:5:5, LARG, PORT, 3:3:3 at df = K-1 = 3 with a confidence limit set at 95%. The CHI-square test places the experimental values within the theoretical expected CHI-square value of 7.81 showing no overall significant difference between these four variables when the 34 trials are considered together.

Table 6 (A-T) shows the precision of both the MPN versus MF methodologies. Since earlier experiments (Table 3, 4) showed a scattering of MPN results within three replicate analyses and no overall significant difference between the two methods it was decided to find out what method was more precise. In order to show the relative precision of both techniques it was decided that the analysis of each water sample, for each experimental trial, be conducted generally in replicates of 10, for both the MPN and MF methods. Initially, (Table 6A-C) both the large and portable incubators were used as MF variables but since there were no differences between the two incubators here and in Tables 3 and 4, only the portable incubator was used for the remainder of the MF experiments. Table 6, like Table 3 reveals the inconsistency of the MPN data within the individual replicate analyses in an experimental trial, while the MF data appeared more uniform. Both the geometric and arithmetic means are shown. When the arithmetic mean approaches the geometric mean the data are found to be more uniform. Generally the MF replicate data show similar geometric and arithmetic means while the MPN data are more irregular.

During the time the effluent sewage samples were being comparatively analyzed by both the MPN and MF techniques in replicate trial experiments, typical metallic-sheen producing colonies were selected for identification (API strips) for use in the subsequent pure culture study. The following indicates the percentages of organisms identified: Out of 200 isolates, 30% were Escherichia coli, 24% Klebsiella pneumoniae, 16% Aeromonas hydrophila, 12% Enterobacter cloacae, 10% Enterobacter agglomerans, and 8% Citrobacter freundii.

Also, various strain biotypes of each of these bacterial species were encountered during this study. As mentioned previously, the non-coliform, Aeromonas hydrophila, which normally produces a more pin point sheen colony as compared to the true coliforms, could normally be eliminated from the counting procedure with the use of a portable fluorescent light to enhance the reflection of light from true coliform colonies. This organism was therefore not included in the preceding MF data.

Table 7 shows the statistical summation of the foregoing data presented in Table 6. Analyses of variance and Duncan's multiple range test were performed again for each replicate experiment (6A-T) and for each sample analyzed in replicate. The column on the extreme left of the table shows the date and source of the samples analyzed within each experimental trial the number of replicates and then the column of mean values. The next column shows the geometric mean values of each replicate set of data for each variable. The F and df values are presented in the next succeeding columns and at the extreme right of the table the variables are ranked descending from highest to lowest values as observed in Table 4. These variables are also ranked together or separately in bracketed groups. Variables appearing together in the same bracketed group are not significantly different from one another. This last column will show that there were no significant differences between the three variables 5:5:5, 3:3:3 and portable (MF filtrations) in 7 out of 20 experimental trials or 35% of all trials and that the portable variable is associated with the 5:5:5 series 10 out of 20 times or 50% of the time and is also associated with the 3:3:3 series (separately) 10 out of 20 times or 50% of the time.

The "portable" MF variable is associated with both the 5:5:5 and 3:3:3 MPN series 12 out of 20 times or 60% of the time. The MF variable appears by itself 40% of the time, generally as the highest variable (7 times highest, 1 times lowest). Interestingly, the 5:5:5 MPN series appears with the 3:3:3 MPN series, in the same groupings 18 out of 20 times or 90% of the time even though the MPN replicate trial data is observed to scatter tremendously within each replicate analyses (Table 6). However, if both the 5:5:5 and 3:3:3 MPN series scatter at the same rate and at the same numerical direction these two series should appear together at the same directional rate. The geometric means of the replicate data appears to correctly compensate in the averaging process for this observed non-uniformity of replicate MPN analyses. Since, in the MF replicate data, the arithmetic mean approaches the geometric means these arithmetic means could also have been used in the averaging of the MF data for these statistical analyses. This is not true for the MPN data.

Table 8 shows the frequency of occurrence of the ranked data presented in Table 7 using the four variables 5:5:5, 3:3:3, portable and large MF variable, appearing in first, second, third, fourth place in the 20 experimental trials (the large incubator for MF incubations was again, used in only 3 of the 20 experimental trials). The CHI-square test to determine the experimental goodness of fit compared to an expected theoretical frequency distribution profile was performed on each of the variables (geometric means of replicate analyses) as they appeared in order of highest to lowest shows values, ie, CHI-square for the 5:5:5, 3:3:3 and portable variables of 1.60, 2.80, 4.90 respectively. A CHI-square test for the 4th variable of the large incubator incubations was not possible due to the lack of data since the use of this incubator was discontinued when it was found in previous experiments (Tables 3,4) that there was a 100% correlation between counts on membrane filters incubated in both the large and/or portable incubators. The above experimental CHI-square values, 1.60, 2.80, 4.90 all fall within the theoretical frequency distribution pattern where CHI-square at a 95% confidence limit K-1=2, is equal to 5.99. Although there are significant differences within (MPN data) and between the individual replicate

experiments there are no significant differences considering the overall results of analyses carried out by either the 5:5:5, 3:3:3 MPN series or the membrane filtration technique. However, the MF methodology (portable variable) appeared on the high side of the ranking order scale i.e., geometric values appeared in first place 11 times out of the 20 and in second place 6 times, while the MPN methodology appeared on the lowest side, i.e., 8 times in third place and 3 times in fourth place for the 3:3:3 series, and 8 times in second and 8 times in third place, (out of 20 trials) for the 5:5:5 methodology. At this point it would be too presumptuous to say whether the higher (MF methodology) or lower (MPN methodology) is the most accurate side of the numerical order scale even though replicate analyses within a replicate experiment indicate that the MF procedure is to be more precise.

Table 9 (A-P) shows the results of 16 individual replicate experiments using a number of pure coliform culture strains isolated and purified from membrane filters used in previous comparative experiments. This present series of pure culture experiments uses 5 variables (MPN, MF, 5PC, MAC (on key, EMB) to enumerate the number of organisms present in the original 16-18 h pure culture incubation tubes containing the various strains of organisms. The variables used are as indicated, the MPN methodology using the 5:5:5 exponential dilution technique (1), MF methodology and SPC (Standard Plate Count), MacConkey, and EMB (Eosine methylene blue) Agars. Again, a great amount of variability is experienced within an MPN experimental replicate analysis. This has, as before, caused the arithmetic averages of a replicate trial to deviate exponentially from the geometric means. This occurs to a lesser extent in the MF, SPC MacConkey and EMB enumeration techniques, which relies on a direct count of viable microorganisms. The enumeration of strains via the MacConkey and EMB Agars appear to vary quite a bit more as compared to the MF and SPC data. This will be explained in more detail, later in this report.

Table 10 shows the summation of the statistical analyses performed on the individual replicate experiments presented in Table 9 (A-P). An analysis of variance and Duncan's multiple range test were performed on each of these replicate sets of data in a similar manner described in the foregoing tables (Tables 4,7). The data shows from left to right, the strain of bacterium used for the study (the 7 digit number generated by the API computerized index), the number of replicates, the geometric mean values of each variable, F and df values, and the last column, as before, ranks the five variables in successive descending numerical order. This table shows that in 5 out of 16 replicate experiments (31.3%) there were no significant differences between counts obtained by either of the 5 variables tested by the MPN, SPC, MAC, MF, + EMB enumerative techniques. However, the data also shows that the MPN data was separated from the SPC, MacConkey, MF and EMB variables, 6,7,5 and 7 times (37.5%, 43.8%, 31.3% + 43.8% of the time) respectively. On the other hand, the MF data was separated from the SPC, MacConkey and EMB data, 0, 6, and 2 times (0%, 37.5%, + 12.5% of the time) respectively. In 16 separate experimental trials both the SPC and MF data appear together 16 out of 16 times or show a 100% correlation with each other; also, the SPC and MF data are together with the EMB data 14 out of 16 times or 87.5% of the experiments. Initially, the rationale for using the SPC, MAC, and EMB Agars as plating media was to use these three different types of media as reference media where the counts obtained with these three media would be referred to as absolute counts, and that all counts obtained via the MPN and MF methodology would be compared with these absolute values. Obviously, however, the crystal violet (1) in the MacConkey Agar is slightly inhibitory towards the growth of the enteric coliform strains used in this study. The crystal violet is used in this medium to generally inhibit Gram positive organisms so that only enterics are allowed to be isolated and purified on this medium with more ease. The methylene blue (1) used in the EMB medium is only slightly inhibitory to these enteric strains, as it shows a fairly good correlation with the MF and SPC data. However, the SPC results clearly demonstrate its growth supporting properties and it is for this reason that it is used as the standard methods agar to enumerate total viable microbial counts in foods and clinical specimens analysed in various microbiology laboratories throughout the world (1).

Table 11 shows the frequency of occurrence of the experimental variables presented in Tables 9 and 10 - i.e., from highest to lowest. The CHI-square test for the goodness of fit was used to analyse the frequency of the rank. The CHI-square test shows a statistically equal distribution of data for both the EMB (CHI-square = 0.88) and SPC (CHI-square = 2.75) plating media i.e., as compared to a theoretical value of CHI-square = 9.49 for K-1=4 degrees of freedom. The observed CHI-square statistic calculated for the MPN, MAC and MF data are 25.88, 15.88 and 13.88 respectively showing an uneven distribution of the rank for these three variables. The MPN data appears on the extreme high side (11 times in first place) of the frequency distribution curve, while the MacConkey data appear generally on the lowest side (i.e., 9 times in fifth, or last place) of the distribution curve. The MF data, although unevenly distributed (expect a theoretical distribution of 16/5 = 3.2 in each of first, second, third, fourth and fifth place) throughout the entire table, show an observed pattern directly in the center of a theoretical frequency distribution curve (first and last place = 0) which indicates a better geometric mean fit for the observed MF data - even more so than the EMB and SPC data.

DISCUSSION

Over the years it has become accepted that the coliform index constitutes a reasonably good and accurate measure of quantitating fecal pollution. It is necessary that the method employed to estimate coliform concentrations should yield statistically reliable results, over a wide variety of samples with different physical, chemical and biological characteristics (4).

This present study was based on the enumeration of coliforms by both the MF and MPN methodology on water samples obtained from basically three sources - the Red River, Assiniboine River and the South End Pollution Control Centre, Winnipeg, Manitoba. The fourth source is the pure culture analysis carried out in this study. These sample sources should contain many physical and biochemical parameters that might offset the bias of either the MF or MPN methodologies. The MF methodology proved to be the most precise and most accurate technique of the two since in this methodology the counts were not offset by these variable parameters. Other workers using different approaches encountered similar findings (10, 11, 12, 13). On the otherhand, the MPN methodology was observed to fluctuate drastically within each set of replicate data. This is not too suprising since in the MF methodology one is making direct counts of metallic sheen colonies while the accuracy of the MPN methodology relies entirely on the number of tubes inoculated in each dilution series, the error becoming smaller with an increasing number of tube inoculations.

One has to be careful also in interpretating MPN data since MPN estimates represent a mathematical attempt to define a discrete estimate of the most likely bacterial density and would therefore be no more reliable than the experimental technique on which the evaluation is based.

One must, at this time, recall the necessary use of geometric averaging of the data, since there was so much scattering of bacterial estimates via the MPN methodology within each replicate experiment. The MF methodology on the other hand as mentioned previously, gives a direct estimate of bacterial densities and thus was expected to be a more precise method over the MPN methodology. As long as laboratory and field personnel are trained in aseptically manipulating the MF lab/Field Kit and enumerating accurately the true, metallic sheen colonies which represent the true coliform organisms present in a water sample, the MF technique is a precise and accurate method. False positives can be reduced in the counting procedure.

The use of statistical analyses of variance and Duncan's Multiple Range Test to rank the geometric means of three rather extensive sets of data comparing counts obtained by both the MPN and MF techniques on raw and impure water sources showed an equal distribution pattern of results for each variable tested via the CHI-square-goodness-of-fit test (Tables 5,7, 10). For these rather raw and impure waters the MPN series is favoured on the low side of the geometric range of the data, while the MF methodology appears on the opposite side, or on the higher side of this numerical range. However, other investigators have generally found the opposite trend for the MPN data (4,11). These investigators, plus others also agree that the median ratios of densities of the two methods indicate that MF counts on the average (4) are undoubtedly smaller than corresponding MPN's, a sizable portion of the difference may be attributed simply to the fact that the most probable, mathematically considered, is a biased number of the true density. The arithmetic means of replicate MPN's tend to be too high by a factor of 23% in a 5:5:5 tube test and a factor of 43% in a 3:3:3 tube test (4 + 11).

Standard Methods for the Examination of Water and Wastewater (1) also states that "It is desirable to bear in mind that unless a large number of portions of sample are examined, the precision of the fermentation test is rather low." Also, it states (1), "Even when five fermentation tubes are employed, the precision is not of high order." It is for this reason that the **geometric** and **not arithmetic** mean was used in the averaging process for all replicate results obtained in this present study. However, even though the MF methodology appeared on the high side and the MPN ranked on the low side of the data for raw and impure water, the arrangement of data is of no great concern as it is difficult to compare the MF data, on an absolute basis with the MPN data since the MPN replicate data is so unreliable. However, since the geometric means were exclusively used in this present study, the mean values obtained for both the MPN and MF techniques probably more closely reflect true coliform counts. The occasional high or low replicate counts experienced in the MPN methodology would not as drastically deflect mean values towards these outlier values. Thus, even if the MF enumerative procedure is on the high side for raw and impure waters it, in fact, may represent a more accurate representation of the water sources. In the past, other investigators used only the arithmetic means for calculating replicate averages. This data suggests that the geometric means must be used for similar comparative studies. Therefore no effort has been made here to use the arithmetic means that occur in some tables. Also, since many antagonistic components in the water would probably be filtered through the membranes during the filtration process, most coliform organisms developing on the membranes would grow into visible metallic sheen colonies independant of any interreactions with each other or other factors. This is not true of the MPN technique since other types of organisms may be interacting in either a positive or negative manner with the coliform organisms present in the inoculated MPN tubes. The inhibition of coliforms in the MPN tubed media would, for example, result in lower estimates - as experienced in this present study.

The limited amount of identifications performed on the metallic sheen colonies found on the membranes examined showed that generally with one exception, ie., A. hydrophila, only coliforms produced well defined golden-green metallic sheen colonies. HSU and Williams (28) found that overall positive varification rates of MF colonies in brilliant green bile MPN media was 90%. The present study showed similar false positive varification (10%) of red and pin point sheen colonies. The organism most often encountered as false positive could usually be eliminated in the counting procedure with the use of a fluorescent lamp which enhances the sheen of true coliforms more than A. hydrophila.

In 1976, Dutka and Tobin (23) pointed out that there may not be any universal coliform es-

timation procedures and that local conditions often will dictate the success of a particular procedure in isolating and enumerating specific coliform populations. The media used by these investigators to enumerate the coliform group of organisms present in various water supplies appeared to show a certain selectivity bias with certain types of organisms. They therefore suggest that what is required are " Reference procedures, against which locally used procedures can be measured and their validity as the most appropriate procedure verified." For this reason, a number of pure cultures isolated in both the MF and MPN techniques were se'ected for the pure culture study described herein - so the enumerative potential of both techniques would theoretically be the same and thus normalized.

This pure culture study compared counts of the various strains selected by both the MPN and MF procedures to three standard methods agars, SPC, MacConkey plus EMB agars. This study showed the majority of MPN values in the expected high side of the ranked data, the MacConkey plating data on the extreme low side of the ranked data, and the MF data directly in between, the MF data agreeing most favourably with both SPC and EMB data. The last two agars were used as absolute reference standards. Although the MF data bears no means on the extreme low or high side, i.e., in first or last place, its position in the center strongly suggests that it is right in the middle of a theoretical frequency distribution curve showing excellent correlation with the reference standards whereas the MPN data lies outside the 95% confidence limits of this curve showing poor correlation with the standard method agars. The counts obtained on the MacConkey agar can be discounted for use as true reference counts, since it is believed that the crystal violet in this agar exerted drastic inhibitory effects on the pure cultures used in this study.

It is agreed that other statistical evaluations could have been carried out for the data presented here. However, this present report's main aim was to show that the MF procedure was at least on par with the MPN methodology and could be a valuable tool for use in the field. This present study has shown more than anticipated. This study shows that the MF procedure in comparison to the MPN methodology is much more precise and accurate in enumerating coliforms in water.

CONCLUSIONS

1. The MF data showed excellent precision and accuracy in enumerating coliforms from raw and impure waters, and in the pure culture study. Comparing a single filtration with an MPN inoculation, i.e., by the 5:5:5 series, the precision of the MF technique is many fold more accurate than the MPN procedure (4,11,30). Since the MF methodology is more precise and accurate over the MPN methodology it should be used whenever possible, i.e., especially in the field, by trained personnel who can correct problem areas on site.
2. The MPN data, showed acceptable correlation with the rest of the data when the overall results are examined and the counts based on raw and impure waters, but poor correlation with the standard method agars used in the pure culture study.
3. A fluorescent light should be used by trained field personnel to visualize sheen producing coliform colonies during the enumeration procedure, to minimize counting of A. hydrophila colonies.
4. Both the MPN and MF techniques may preferentially enumerate certain types of coliforms (23) but the pure culture study conducted in this report using predominant strains which appeared in both techniques, showed poor correlation of counts obtained via the MPN methodology and the standard method agars and excellent correlation of counts obtained by the MF procedure and the same agar controls. For future comparison studies, other media (blood agar, brain heart infusion agar, MacConkeys without crystal violet, etc.) should also be used in the investigations, using additional pure coliform cultures as well as mixed cultures.
5. Studies of this nature must use reference standards as guide lines for similar comparison studies since simple comparative counts may have little meaning. Also, other investigators generally have used the arithmetic means for averaging their data. The geometric means must invariably be used to compensate for data fluctuations experienced by the tubed MPN technique. Also, these fluctuations by themselves give an indication as to the imprecision and inaccuracy of the MPN methodology unless a number of replicates are run on a sample of water analyzed.
6. A more reliable technique to replace the internationally accepted MPN procedure should be sought for use in food microbiology laboratories for the analyses of food and food products. Many governmental agencies are now using the MF procedure for the routine analyses of water/ice samples (experimentation is also now taking place in some laboratories in favour of the use of the MF procedure for certain foods).
7. More research is required to search for methods that would perhaps yield more direct tests for the enumeration and/or detection of microbial pathogens instead of indicator organisms present in water/ice and food products.

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Table 1. Evaluation of two leading brands (Gleman & Millipore) to membrane filters versus the multiple tube fermentation technique (MPN analyses) for the enumeration of total coliforms in water (values expressed as coliforms/100 mL sample).

DATE SOURCE	DIL.	LTB 24 hr		LTB 48 hr		LTB 48 hr BGB 48 hr		Endo MF					Endo Les				
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	GA	MU	GN	ME	MA	GA	MU	GN	ME	MA
May 24, 1977																	
Red River	10^{-1}	220	230	1100	2100	460	230	2600	500	1200	2800		2600	1700	6400	3200	
May 25, 1977																	
Red River Upstream	10^{-1}	2400	230	9200	1060	2400	1200	500	300	400	300		900	800	700	900	
Red River Downstream		3500	4600	5400	11000	3500	4600	900	1900	2700	700		3500	2900	2800	2400	
May 30, 1977																	
Red River	10^{-1}	330	430	2200	2400	700	2400	4200	500	3600	1200		5400	2800	9000	2700	
June 6, 1977																	
Red River Upstream	10^{-1}	230	390	460	1500	330	750	1200	1700	2800	1000		2400	1200	1200	1100	
Red River Downstream	10^{-1}	330	1500	1700	1500	790	1500	2300	800	1100	1100		1800	1500	1800	1300	
June 7, 1977																	
Red River Upstream	10^{-1}	1300	2400	2400	4600	1300	2400	1700	1400	2500	1900		3900	2600	4000	2700	
Red River Downstream	10^{-1}	3500	4600	3500	4600	1700	1600	2600	1800	3100	2100		2100	2200	2700	2300	
June 8, 1977																	
Red River	10^{-1}	1300	1500	2200	4600	1700	1500	1600	1300	1400	1200		2500	1900	2400	1600	
June 13, 1977																	
Red River Upstream	10^{-1}	2200	930	2200	11000	2200	11000	1700	1800	1600	2100	1800	1900	1800	2600	1900	900
Red River Downstream	10^{-1}	1100	930	3500	4600	1700	4600	1800	1300	1500	1800	1200	2100	1400	2100	1500	800
June 15, 1977																	
Red River Upstream	10^{-1}	490	930	1300	2400	790	2400	1400	900	1100	1700	900	1500	900	1500	1500	500
Red River Downstream	10^{-1}	1300	1600	9200	4600	3500	4600	6300	1500	3200	2500	2500	5400	1800	4900	2600	1800
June 20, 1977																	
Red River	10^{-1}	16000	11000	16000	11000	16000	24000	7000		18400			12000		19000		14000
June 21, 1977																	
Red River Upstream	10^{-1}	9200	4600	16000	11000	9200	4600	6100		6200	6700	5900	7100	6500	8600	6700	6200
Red River Downstream	10^{-1}	5400	11000	16000	11000	5400	11000	4700	3900	4600	5200	3400	6300	5150	4100	5100	5200
June 22, 1977																	
Red River Upstream	10^{-1}	1700	4600	3500	11000	3500	1500	1600	1100	3900	2300	2300	3200	2900	3200	3700	2100

Membrane Filters: GA - Gelman Autoclave Paks; MU - Millipore (0.7μ); GN - Gelman Single Wrapped; ME - Millipore Ethylene Oxide Sterilized; MA - Millipore Autoclave Paks

Table 2. Corresponding MPN and MF means of coliform counts expressed in Table 1 (values expressed as coliforms/100 mL sample)

	m Endo Broth						m Endo Les Agar					
	GA	MU	GN	ME	MA	Geo. Means	GA	MU	GN	ME	MA	Geo. Means
MPN values												
5:5:5	2000	1500	2000	1700	2100	1900	2000	1700	2000	1700	3600	2100
3:3:3	2400	1300	2400	2400	4600	2400	2400	2400	2400	2400	4200	2700
MF values	2400	1200	2400	1800	2200	1900	2200	2200	2400	2200	2900	2400

Membrane Filters: GA - Gelman Autoclave Paks; MU - Millipore (0.7μ); GN - Gelman Single Wrapped; ME - Millipore Ethylene Oxide Sterilized; MA - Millipore Autoclave Paks

Table 3A. Counts obtained by the multiple-tube fermentation technique (MPN values) versus the membrane filtration (MF) procedure. (The LARGE incubator refers to the large Puffer-Hubbard incubator, and the portable incubator, the MF field kit; both were held at 35°C; values expressed as coliforms/100 mL sample).

DATE & SOURCE	MPN Values; 48 hr LTB, & 48 hr BGB				MF Results			
	5:5:5	5:5:5 Average	3:3:3	3:3:3 Geometric Means	Large Incubator Values	Large Incubator Average	Portable Incubator Values	Portable Incubator Geometric Means
June 27, 1977								
Red River Upstream	5400		4600		3100		3500	
	7500	4100	4600	4600	4400		2800	
	1700		4600		5000		1300	
					2000	3300	1700	2300
					3000		3100	
June 28, 1977								
Red River Upstream	5400		2400		6000		7000	
	2200		930		6200		6500	
	1700	2700	2400	1700	6500		5500	
					5700		6600	6500
					6200	6100	7200	
Red River Downstream	340		4600		4400		4800	
	2400		4600		4800		5200	
	2400	1300	4600	4600	5200		5400	
					4200	4900	5600	
					5400		4000	5000
June 29, 1977								
Red River Upstream	280		930		4000		3800	
	700		1500		3800		4000	
	340	410	150	590	4100		4200	
					5000		3200	
					5200	4400	3800	3800
Red River Downstream	1700		2100		3000		3700	
	1300		2400		2800		4300	
	280	850	1500	2000	3000		3100	
					3400	3100	4000	
					3100		3400	3700

Table 3B. Counts obtained by the multiple-tube fermentation technique (MPN values) versus the membrane filtration (MF) procedure. (The LARGE incubator refers to the large Puffer-Hubbard incubator, and the portable incubator, the MF field kit; both were held at 35°C; values expressed as coliforms/100 mL sample).

DATE & SOURCE	MPN Values; 48 hr LTB, & 48 hr BGB				MF Results			
					Large Incubator		Portable Incubator	
	5:5:5	5:5:5 Geometric Means	3:3:3	3:3:3 Average	Values	Geometric Means	Values	Geometric Means
July 4, 1977								
Red River Upstream	3500		2400		2800		5400	
	1400		2400		2800		5500	
	3500	2600	11000	4000	2800		6000	
					6000		4400	
					8300	4100	5300	5300
Red River Downstream	5400		2100		4000		4000	
	3500		11000		4000		5000	
	490	2600	4600	4700	3600		4500	
					5800		4100	
					4400	4300	4900	4500
July 6, 1977								
Red River Upstream	330		930		6400		6000	
	340		230		4800		5200	
	1100	500	430	450	4200		5000	
					5200	5100	4200	4800
Red River Downstream	310		2100		2400		3800	
	3500		930		3600		3800	
	790	1100	1500	1400	3400		3200	
					4400		3500	
					3800	3500	3700	3600
July 11, 1977								
Lake Winnipeg	700		430		900		1000	
	490		930		1000		900	
	490	550	1200	780	800		800	
					900	900	1000	
							800	900

Table 3C. Counts obtained by the multiple-tube fermentation technique (MPN values) versus the membrane filtration (MF) procedure. (The LARGE incubator refers to the large Puffer-Hubbard incubator, and the portable incubator, the MF field kit; both were held at 35°C; values expressed as coliforms/100 mL sample).

DATE & SOURCE	MPN Values; 48 hr LTB, & 48 hr BGB				MF Results			
	5:5:5	5:5:5 Average	3:3:3	3:3:3 Average	Large Incubator Values	Large Incubator Average	Portable Incubator Values	Portable Incubator Average
July 12, 1977								
Assiniboine R. Upstr.	9200		11000		13800		8000	
	9200		11000		1200		8200	
	5400	7700	11000	11000	9800		7200	
					9200	6200	8000	
							7600	7800
Assiniboine R. Downstr	4900		4300		7400		7600	
	4900		4300		7600		5800	
	4900	4900	2300	3500	6000		5400	
					6200		5800	6100
					6800	6800		
July 13, 1977								
Assiniboine R. Upstr.	2300		4300		5400		4000	
	4900		4300		4200		4000	
	11000	5000	24000	7600	4000		4200	
					4400		5200	
					4000	4400	3800	4200
Assiniboine R. Downstr	4900		4300		4400		4200	
	7900		4300		3800		4600	
	4900	5700	7500	5200	3800		5800	
					3400		4400	
					5400	4100	4000	4600
July 13, 1977								
Red River Upstream	2400		930		2200		3000	
	790		1500		2000		2400	
	790	1100	430	840	2400		3800	
					3200		3800	
					3600	2600	1600	2800
Red River Downstream	2400		930		2200		2400	
	490		430		2000		2000	
	790	980	930	720	3400		1800	
					2200		2800	
					2400	2400	2000	2200

Table 3D. Counts obtained by the multiple-tube fermentation technique (MPN values) versus the membrane filtration (MF) procedure. (The LARGE incubator refers to the large Puffer-Hubbard incubator, and the portable incubator, the MF field kit; both were held at 35°C; values expressed as coliforms/100 mL sample).

DATE & SOURCE	MPN Values; 48 hr LTB, & 48 hr BGB				MF Results			
	5:5:5	5:5:5 Average	3:3:3	3:3:3 Average	Large Incubator Values	Large Incubator Average	Portable Incubator Values	Portable Incubator Average
July 18, 1977								
Assiniboine River Downstream	4900		9300		9000		8000	
	7900		7500		6600		7800	
	4900	5700	11000	9200	6200		9000	
					8800		6400	
					7800	7600	9000	8000
July 20, 1977								
Assiniboine River Upstream	4900		4300		3400			
	4900		24000		4800		Incubator	
	7900	5700	9300	9900	5600			
					4600		shut off	
					3000	4200		
							No results	
Assiniboine River Downstream	7900		9300		4800			
	13000		9300		4800			
	4600	7800	4300	7200	4600			
					5200	4800		
					4800			

Table 3E. Counts obtained by the multiple-tube fermentation technique (MPN values) versus the membrane filtration (MF) procedure. (The LARGE incubator refers to the large Puffer-Hubbard incubator, and the portable incubator, the MF field kit, both were held at 35°C; values expressed as coliforms/100 mL sample).

DATE & SOURCE	MPN Values; 48 hr LTB, & 48 hr BGB				MF Results			
					Large Incubator Values	Large Incubator Average	Portable Incubator Values	Portable Incubator Average
July 25, 1977								
Assiniboine River Upstream	3300		4300		3200		4800	
	7000		4300		3400		2800	
	3300	4200	4300	4300	3800		4200	
					3000		4800	
					3800	3400	4300	
Assiniboine River Downstream	5400		11000		5600		2200	
	1700		4600		5000		3000	
	5400	3700	2400	5000	4600		4200	
					4000		3600	
					3000	4300	3200	3200
July 26, 1977								
Assiniboine River, Headingly	3300		4300		3200		4800	
	4600		4300		2000		2600	
	4900	4200	2300	3500	4200		2000	
					3600		3600	
					4000	3300	2200	2900
August 2, 1977								
Lake Manitoba	130		90		80		70	
	80		90		50		100	
	230	130	90	90	80	68	50	70
August 2, 1977								
Red River Upstream	1300		430		2800		2400	
	2950		1500		3000		2200	
	3500	2400	1500	990	2000		2300	
					2800		2200	
					2400	2600	1900	2200

Table 3F. Counts obtained by the multiple-tube fermentation technique (MPN values) versus the membrane filtration (MF) procedure. (The LARGE incubator refers to the large Puffer-Hubbard incubator, and the portable incubator, the MF field kit; both were held at 35°C; values expressed as coliforms/100 mL sample).

DATE & SOURCE	MPN Values; 48 hr LTB, & 48 hr BGB				MF Results			
	5:5:5	5:5:5 Average	3:3:3	3:3:3 Average	Large Values	Large Incubator Average	Portable Values	Portable Incubator Average
August 3, 1977								
Lake Winnipeg	920		240		190		230	
	240		240	200	200		220	
	350	430	150		180		240	
					190	190	270	240
August 4, 1977								
Red River Upstream	3300		4300		2200		2600	
	4000		4300		3000		2400	
	3300	3500	9300	5600	2200	2400	3000	
							2800	2700
Red River Downstream	1300		9300		3400		3000	
	17000		9300		3400		3800	
	4900	4800	4300	7200	2800		3400	3400
					3200	3200		
August 9, 1977								
Red River Upstream	5400		2400		3000		2400	
	2200		2400		3800		3600	
	5400	4000	2400	2400	3600		2600	
					3500	3500	2900	2800
August 10, 1977								
Red River Upstream	3500		2400		4200		5600	
	2200		2400		4800		4400	
	3500	3000	2400	2400	3600	4200	2400	3900
Red River - Minnetonka	9200		2400		3400		4000	
	3500		4000		3600		4600	
	5400	5600	4000	3400	4400		3800	
					3800	3800	4400	4200

Table 3G. Counts obtained by the multiple-tube fermentation technique (MPN values) versus the membrane filtration (MF) procedure. (The LARGE incubator refers to the large Puffer-Hubbard incubator, and the portable incubator, the MF field kit; both were held at 35°C; values expressed as coliforms/100 mL sample).

DATE & SOURCE	MPN Values; 48 hr LTB, & 48 hr BGB				MF Results			
	5:5:5	5:5:5 Average	3:3:3	3:3:3 Average	Large Values	Incubator Average	Portable Values	Incubator Average
August 15, 1977								
	24000		2300		9600		11000	
	4900		2300		11800		11000	
	7900	9800	2300	2300	8800		10000	
					11000	100000	11000	11000
Assiniboine River	11000		24000		8800		6400	
	7900		21000		8600		10000	
	3300	6600	9300	17000	9600		8000	
					9000		9000	
					9200	9000	7200	8000
August 16, 1977								
Assiniboine River	11000		7500		9600		10000	
Upstream	13000		1500		12000		11000	
	4900	8900	2400	3000	8800		9800	
					10000		10000	
					9200	9900	9600	10000
Assiniboine River	13000		15000		11000		11000	
Downstream	4900		2300		11000		9600	
	4900	6800	15000	8000	10000	11000	10000	10000
August 17, 1977								
Assiniboine River	16000		11000		12000		12000	
Upstream	10000		11000		13000		13000	
	16000	14000	11000	11000	13000	13000	13000	13000
Assiniboine River	16000		11000		13000		16000	
Downstream	16000		11000		12000		14000	
	9200	13000	11000	11000	14000	13000	13000	
							13000	14000

Table 4. Statistical summation of data presented in Table 3.

Samples	No Replicates 5:5:5	3:3:3	LARG	PORT	Geometric Mean Values (Coliform counts /100 ml sample) 5:5:5	3:3:3	LARG	PORT	F Values	d.f.	Successive Ranking of Experimental Variables [Variables with no Significant Differences within Bracket]
(a)											
June 27/77											
*RRU	3	3	5	5	4100	4600	3300	2300	1.78	3,12	(3:3:3 5:5:5 LARG PORT)
June 28/77											
RRU	3	3	5	5	2700	1700	6100	6500	13.08	3,12	(PORT LARG) (5:5:5 3:3:3)
*RRD	3	3	5	5	1300	4600	4900	5000	6.78	3,12	(PORT LARG 3:3:3) (5:5:5)
June 29/77											
RRU	3	3	5	5	410	590	4400	3800	19.28	3,12	(LARG PORT) (3:3:3 5:5:5)
RRD	3	3	5	5	850	2000	3100	3700	8.63	3,12	(PORT LARG 3:3:3) (5:5:5)
(b)											
July 4/77											
RRU	3	3	5	5	2600	4000	4100	5300	5.46	3,12	(PORT LARG 3:3:3 5:5:5)
RRD	3	3	5	5	2100	4700	4300	4500	1.43	3,12	(3:3:3 PORT LARG 5:3:5)
July 6/77											
RRU	3	3	4	5	500	450	5100	4800	3.11	34,18	(PORT LARG) (5:5:5 3:3:3)
RRD	3	3	5	5	1100	1400	3500	3600	5.46	3,12	(PORT LARG) (3:3:3 5:5:5)
July 11/77											
Lake Winnipeg	3	3	4	5	550	780	900	900	2.66	3,11	(LARG PORT 3:3:3) (3:3:3 5:5:5)
(c)											
July 12/77											
*ARU	3	3	4	5	7700	11000	6200	7800	0.53	3,11	(3:3:3 PORT 5:5:5 LARG)
*ARD	3	3	5	4	4900	3500	6800	6100	8.99	3,11	(LARG PORT)(PORT 5:5:5)(3:3.3)
July 13/77											
ARU	3	3	5	5	5000	7000	4400	4200	0.92	3,12	(3:3:3 5:5:5 LARG PORT)
ARD	3	3	5	5	5700	5200	4100	4600	1.72	3,12	(5:5:5 3:3:3 PORT LARG)
July 13/77											
*RRU	3	3	5	5	1100	800	2600	2800	6.62	3,12	PORT LARG 5:5:5 3:3:3
*RRD	3	3	5	5	980	720	2400	2200	7.78	3,12	(LARG PORT) (5:5:5 3:3:3)
(d)											
July 18/77											
ARD	3	3	5	5	5700	9200	7000	8000	3.37	3,12	(3:3:3 PORT LARG) (5:5:5)
July 20/77	incubation shutoff, no results										
(e)											
July 25/77											
ARU	3	3	5	5	4200	4300	3400	4300	1.01	3,12	(PORT 3:3:3 5:5:5 LARG)
ARD	3	3	5	5	3700	5000	4300	3200	0.72	3,12	(3.3:3 LARG 5:5:5 PORT)
July 26/77											
AR Head.	3	3	5	5	4200	3500	3300	2900	0.90	3,12	(5:5:5 3:3:3 LARG PORT)
Aug 2/77											
L. Manitoba	3	3	3	3	130	90	68	70	2.44	3,08	(5:5:5 3:3:3 PORT LARG)
RRU	3	3	5	5	2400	990	2600	2200	4.46	3,12	(LARG 5:5:5 PORT)(3:3:3)
(f)											
Aug 3/77											
L. Winnipeg	3	3	4	4	430	200	190	240	3.74	3,10	(5:5:5) (PORT 3:3:3 LARG)

Table 4. continued.

Samples	No Replicates 5:5:5	3:3:3	LARG	PORT	Geometric Mean Values (Coliform counts /100 ml sample) 5:5:5	3:3:3	LARG	PORT	F Values	d.f.	Successive Ranking of Experimental Variables [Variables with no Significant Differences within Brackets
Aug 4/77											
*RRU	3	3	3	4	3500	5600	2400	2700	7.42	3,07	(3:3:3) (5:5:5 PORT LARG)
*RRD	3	3	4	3	4800	7200	3200	3400	1.08	3,09	(3:3:3 5:5:5 PORT LARG)
Aug 9/77											
RRU	3	3	4	4	4000	2400	3500	2800	2.36	3,10	(5:5:5 LARG PORT) (3:3:3)
Aug 10/77											
RRU	3	3	3	3	3000	2400	4200	3900	2.73	3,08	(LARG PORT 5:5:5) (PORT 5:5:5 3:3:3)
RR-Minne	3	3	4	4	5600	8400	3800	4200	2.03	3,10	(5:5:5 PORT LARG 3:3:3)
(g) Aug 15/77											
ARU	3	3	4	4	9800	2300	10000	11000	12.73	3,0	(PORT LARG 5:5:5) (3:3:3)
ARD	3	3	5	5	6600	17000	9000	8000	4.20	3,12	(3:3:3) (LARG PORT 5:5:5)
Aug 16/77											
ARU	3	3	5	5	8900	3000	9900	10000	6.92	3,12	(PORT LARG 5:5:5) (3:3:3)
ARD	3	3	3	3	6800	8000	11000	10000	0.36	3,08	(LARG PORT 3:3:3 5:5:5)
Aug 17/77											
ARU	3	3	3	3	14000	11000	13000	1300	1.27	3,08	(5:5:5 PORT LARG 3:3:3)
ARD	3	3	3	4	13000	11000	13000	14000	1.27	3,09	(PORT 5:5:5 LARG 3:3:3)

*RRH - Red River Up Stream
*RRD - Red River Down Stream
*ARU - Assiniboine River Up Stream
*ARD - Assiniboine River Down Stream

Table 5. Frequency of occurrence of experimental variables presented in Tables 3 and 4.

VARIABLE	HIGHEST	SECOND	THIRD	LOWEST	TRIALS	DEGREES OF FREEDOM	CHI-SQUARE
5:5:5	7	7	11	9	34	K-1=3	1.29
3:3:3	9	4	8	13	34	K-1=3	4.82
LARG	7	12	8	7	34	K-1=3	2.00
PORT	11	11	7	5	34	K-1=3	3.18
TOTALS	34	34	34	34			

Table 6A. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF	
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr.		LTB 48 hr BGB 48 hr		Portable Incubator	Large Incubator
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3		
August 22, 1977											
Red River	10^{-1}	3,500	11,000	3,500	4,600	5,400	11,000	5,400	4,600	7,200	7,000
		3,500	9,300	1,700	930	9,200	11,000	2,200	2 400	6 200	6,800
		3,500	4,600	3,500	4,600	9,200	4,600	5,400	4 600	6 800	6 800
		9,200	11,000	9,200	4,600	16 000	11 000	9,200	11,000	6 000	7 000
		3,500	4,600	3,500	4,600	16 000	11,000	3,500	11,000	6 400	6 600
		5,400	4,600	5,400	1,500	5,400	11,000	5,400	2 100	7,200	7,000
		3,500	2,400	3,500	2,400	16,000	2,400	5,400	2 400	6,400	6,200
		1,700	4,600	1,700	4,600	16,000	11,000	9,200	4,600	7,200	6,200
		3,500	2,400	3,500	2,400	3,500	4,600	3,500	4,600	7,200	7,000
		5,400	2,400	2,400	2,400	9,200	4,600	2,400	2,400	6,400	6 600
Arithmetic Mean		4,300	5,700	3,800	3,300	11,000	8,000	5,200	5,000	6,700	6,700
Geometric Mean		3,900	4,800	3,400	2,900	9,400	7,300	4,600	4,200	6,700	6,700

Table 6B. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF	
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr.		LTB 48 hr BGB 48 hr		Portable Incubator	Large Incubator
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3.3		
August 24, 1977											
Red River	10^{-1}	3,500	11,000	3,500	11,000	3,500	11,000	3,500	11,000	7,000	5,400
		1,100	11,000	1,100	11,000	5,400	11,000	5,400	11,000	5,600	4,800
		9,200	930	9,200	930	16,000	11,000	16,000	4,600	5,200	5,600
		2,200	2,400	2,200	2,400	16,000	4,600	9,200	2,400	8,400	6,200
		5,400	2,400	5,400	2,400	9,200	4,600	9,200	4,600	6,000	4,400
		1,700	4,600	1,700	4,600	9,200	11,000	5,400	11,000	4,600	5,200
		2,200	2,400	2,200	2,400	16,000	11,000	16,000	2,400	5,800	5,400
		3,500	2,400	3,500	2,400	16,000	4,600	9,200	2 400	6,000	7,200
		5,400	2,400	5,400	2,400	5 400	4,600	5,400	4,600	5 600	5 600
		2,800	2,400	2,200	2,400	11,000	2 400	16 000	2 400	3,800	4,400
Arithmetic Mean		3,700	4,000	3,600	4,100	11,000	8,000	10,000	6,000	5,800	5,400
Geometric Mean		3,100	3,200	3,000	3,200	7,500	6,700	8,400	4,600	5,700	5,400

Table 6C. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF	
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr.		LTB 48 hr BGB 48 hr		Portable Incubator	Large Incubator
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3		
August 29, 1977											
Assiniboine R.	10^{-2}	3,300	9,300	3,300	9,300	4,900	9,300	4,900	9,300	15,200	11,400
		22,000	7,500	13,000	4,300	28,000	15,000	13,000	4,300	13,600	10,200
		7,900	110,000	7,900	110,000	24,000	110,000	7,900	110,000	11,200	9,800
		13,000	4,300	13,000	4,300	24,000	4,300	24,000	4,300	11,200	10,200
		4,900	4,300	4,900	4,300	14,000	24,000	7,000	4,300	10,000	9,400
		4,900	4,300	3,300	4,300	13,000	24,000	7,900	9,300	13,400	9,600
		7,900	9,300	4,900	9,300	24,000	24,000	7,900	9,300	13,600	8,000
		4,600	4,300	3,100	2,300	17,000	15,000	7,000	4,300	10,000	9,800
		4,900	9,300	3,300	4,300	11,000	24,000	7,900	4,300	13,200	11,600
		22,000	2,300	22,000	2,300	54,000	4,300	22,000	4,300	13,800	11,200
Arithmetic Mean		10,000	16,000	7,900	15,400	17,000	25,000	10,000	1,600	13,000	10,000
Geometric Mean		7,700	7,400	7,800	4,900	18,000	16,000	9,600	7,500	12,000	10,000

Table 6D. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr		LTB 48 hr BGB 48 hr		
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	
March 28, 1978										
Primary Effluent South End Pollution Control Centre	10^{-4}	$1.1x10^6$	$2.4x10^6$	$1.1x10^6$	$2.4x10^6$	$1.7x10^6$	$2.4x10^6$	$1.1x10^6$	$2.4x10^6$	$4.5x10^6$
		$1.1x10^6$	$4.6x10^6$	$1.1x10^6$	$4.6x10^6$	$1.7x10^6$	$4.6x10^6$	$1.1x10^6$	$4.6x10^6$	$4.8x10^6$
		$2.2x10^6$	$4.6x10^6$	$2.2x10^6$	$4.6x10^6$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$4.7x10^6$
		$9.2x10^6$	$2.4x10^6$	$9.2x10^6$	$2.4x10^6$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$5.1x10^6$
		$2.8x10^6$	$1.1x10^7$	$2.8x10^6$	$1.1x10^7$	$2.8x10^6$	$1.1x10^7$	$2.8x10^6$	$1.1x10^7$	$4.2x10^6$
Arithmetic Mean		$3.3x10^6$	$2.8x10^6$	$3.3x10^6$	$5.0x10^6$	$6.3x10^6$	$8.0x10^6$	$6.0x10^6$	$8.0x10^6$	$4.7x10^6$
Geometric Mean		$2.3x10^6$	$4.2x10^6$	$2.3x10^6$	$4.2x10^6$	$4.1x10^6$	$6.8x10^6$	$3.5x10^6$	$6.8x10^6$	$4.7x10^6$

Table 6E. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr		LTB 48 hr BGB 48 hr		
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	
April 17, 1978 Primary Effluent South End Pollution Control Centre	10^{-4}	2.8×10^{6}	2.4×10^{6}	1.8×10^{6}	2.4×10^{6}	3.5×10^{6}	4.6×10^{6}	1.8×10^{6}	2.4×10^{6}	5.1×10^{6}
		2.4×10^{6}	9.3×10^{5}	2.4×10^{6}	9.3×10^{5}	3.5×10^{6}	2.4×10^{6}	2.4×10^{6}	2.4×10^{6}	5.0×10^{6}
		2.4×10^{6}	1.5×10^{6}	2.4×10^{6}	9.3×10^{5}	5.4×10^{6}	1.5×10^{6}	2.4×10^{6}	1.5×10^{6}	4.8×10^{6}
		2.4×10^{6}	4.6×10^{6}	2.4×10^{6}	4.6×10^{6}	3.5×10^{6}	4.6×10^{6}	3.5×10^{6}	4.6×10^{6}	5.1×10^{6}
		5.4×10^{6}	4.6×10^{6}	5.4×10^{6}	1.5×10^{6}	9.2×10^{6}	4.6×10^{6}	5.4×10^{6}	1.5×10^{6}	5.0×10^{6}
		1.7×10^{6}	2.4×10^{6}	1.7×10^{6}	2.4×10^{6}	3.5×10^{6}	2.4×10^{6}	1.7×10^{6}	2.4×10^{6}	4.4×10^{6}
		9.2×10^{6}	2.4×10^{6}	9.2×10^{6}	2.4×10^{6}	9.2×10^{6}	2.4×10^{6}	9.2×10^{6}	2.4×10^{6}	4.5×10^{6}
		9.2×10^{6}	2.4×10^{6}	9.2×10^{6}	2.4×10^{6}	9.2×10^{6}	4.6×10^{6}	9.2×10^{6}	4.6×10^{6}	4.7×10^{6}
		9.2×10^{6}	4.6×10^{6}	9.2×10^{6}	4.6×10^{6}	9.2×10^{6}	1.1×10^{7}	9.2×10^{6}	1.1×10^{7}	4.8×10^{6}
Arithmetic Mean		5.0×10^{6}	2.9×10^{6}	4.9×10^{6}	2.5×10^{6}	6.2×10^{6}	4.2×10^{6}	5.0×10^{6}	3.6×10^{6}	4.8×10^{6}
Geometric Mean		4.0×10^{6}	2.5×10^{6}	3.8×10^{6}	2.1×10^{6}	5.6×10^{6}	3.6×10^{6}	4.0×10^{6}	3.0×10^{6}	4.8×10^{6}

Table 6F. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr		LTB 48 hr BGB 48 hr		
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	
April 24, 1978 Final Effluent South End Pollution Control Centre	10^{-4}	5.0×10^{4}	9.0×10^{4}	5.0×10^{4}	9.0×10^{4}	1.7×10^{5}	1.5×10^{5}	1.3×10^{5}	9.0×10^{4}	1.8×10^{5}
		5.0×10^{4}	9.0×10^{4}	5.0×10^{4}	9.0×10^{4}	5.0×10^{4}	9.0×10^{4}	5.0×10^{4}	7.0×10^{4}	3.0×10^{5}
		8.0×10^{4}	4.0×10^{4}	5.0×10^{4}	4.0×10^{4}	9.0×10^{4}	4.0×10^{4}	5.0×10^{4}	4.0×10^{4}	1.0×10^{5}
		5.0×10^{4}	9.0×10^{4}	5.0×10^{4}	9.0×10^{4}	8.0×10^{4}	9.0×10^{4}	8.0×10^{4}	9.0×10^{4}	2.0×10^{5}
Arithmetic Mean		5.8×10^{4}	7.8×10^{4}	5.0×10^{4}	7.8×10^{4}	9.8×10^{5}	9.3×10^{4}	7.8×10^{4}	7.3×10^{4}	2.0×10^{5}
Geometric Mean		5.8×10^{4}	7.3×10^{4}	5.0×10^{4}	7.3×10^{4}	8.8×10^{4}	8.3×10^{4}	7.1×10^{4}	6.9×10^{4}	1.8×10^{5}

Table 6G. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr		LTB 48 hr BGB 48 hr		
		5:5:5	3:3:3	5:5:5	3:3:3	5:5.5	3:3:3	5 5:5	3:3:3	
April 24, 1978 Primary Effluent South End Pollution Control Centre	10^{-4}	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.5x10^6$
		$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$1.5x10^6$	$1.6x10^7$	$4.6x10^6$	$9.2x10^6$	$1.5x10^6$	$10.4x10^6$
		$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$8.7x10^6$
		$5.4x10^6$	$4.6x10^6$	$1.7x10^7$	$1.5x10^6$	$5.4x10^6$	$1.1x10^7$	$1.7x10^7$	$2.1x10^6$	$10.7x10^6$
		$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$4.6x10^6$	$9.9x10^6$
Arithmetic Mean		$9.8x10^6$	$7.2x10^6$	$1.2x10^7$	$5.9x10^6$	$1.1x10^7$	$8.0x10^6$	$1.2x10^7$	$6.0x10^6$	$9.8x10^6$
Geometric Mean		$9.2x10^6$	$1.5x10^6$	$1.2x10^7$	$4.0x10^6$	$1.0x10^7$	$7.8x10^6$	$1.2x10^7$	$4.5x10^6$	$9.8x10^6$

Table 6H. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr		LTB 48 hr BGB 48 hr		
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	
May 1, 1978 Final Effluent South End Pollution Control Centre	10^{-4}	$3.3x10^5$	$2.3x10^5$	$3.3x10^5$	$2.3x10^5$	$4.9x10^5$	$4.3x10^5$	$4.9x10^5$	$2.3x10^5$	$9.0x10^5$
		$3.3x10^5$	$2.3x10^5$	$5.1x10^5$	$2.3x10^5$	$3.3x10^5$	$4.3x10^5$	$3.3x10^5$	$4.3x10^5$	$6.0x10^5$
		$4.6x10^5$	$4.3x10^5$	$3.3x10^5$	$4.3x10^5$	$4.6x10^5$	$4.3x10^5$	$3.3x10^5$	$4.3x10^5$	$7.0x10^5$
		$2.3x10^5$	$9.0x10^4$	$2.3x10^5$	$9.0x10^4$	$1.1x10^5$	$9.0x10^4$	$3.3x10^5$	$9.0x10^4$	$8.0x10^5$
		$4.9x10^5$	$4.3x10^5$	$4.9x10^5$	$4.3x10^5$	$4.9x10^5$	$4.3x10^5$	$4.9x10^5$	$4.3x10^5$	$6.0x10^5$
Arithmetic Mean		$3.7x10^5$	$2.8x10^5$	$3.8x10^5$	$2.8x10^5$	$3.8x10^5$	$3.6x10^5$	$3.9x10^5$	$3.2x10^5$	$7.2x10^5$
Geometric Mean		$3.6x10^5$	$2.5x10^5$	$3.6x10^5$	$2.4x10^5$	$3.3x10^5$	$3.1x10^5$	$3.9x10^5$	$2.8x10^5$	$7.1x10^5$

Table 6I. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr		LTB 48 hr BGB 48 hr		
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	
May 1, 1978 Primary Effluent South End Pollution Control Centre	10^{-4}	$3.5x10^6$	$4.6x10^6$	$1.3x10^6$	$4.6x10^6$	$3.5x10^6$	$1.1x10^7$	$1.3x10^6$	$1.1x10^7$	$5.0x10^6$
		$5.4x10^6$	$1.1x10^7$	$5.4x10^6$	$1.1x10^7$	$5.4x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$4.2x10^6$
		$1.1x10^6$	$4.6x10^6$	$1.1x10^6$	$2.4x10^6$	$1.4x10^6$	$4.6x10^6$	$1.4x10^6$	$4.6x10^6$	$4.8x10^6$
		$9.2x10^6$	$2.4x10^6$	$5.4x10^6$	$2.4x10^6$	$1.6x10^7$	$4.6x10^6$	$9.2x10^6$	$2.4x10^6$	$7.3x10^6$
		$1.4x10^6$	$4.6x10^6$	$1.4x10^6$	$4.6x10^6$	$2.2x10^6$	$4.6x10^6$	$2.2x10^6$	$4.6x10^6$	$4.6x10^6$
Arithmetic Mean		$4.1x10^6$	$5.4x10^6$	$2.9x10^6$	$5.9x10^6$	$4.4x10^6$	$7.2x10^6$	$4.9x10^6$	$6.7x10^6$	$5.2x10^6$
Geometric Mean		$3.1x10^6$	$4.8x10^6$	$2.3x10^6$	$4.2x10^6$	$3.9x10^6$	$6.5x10^6$	$3.2x10^6$	$5.7x10^6$	$5.1x10^6$

Table 6J. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr		LTB 48 hr BGB 48 hr		
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	
May 8, 1978 Final Effluent South End Pollution Control Centre	10^{-4}	$4.9x10^5$	$9.3x10^5$	$3.3x10^5$	$9.3x10^5$	$4.9x10^5$	$1.5x10^6$	$3.3x10^5$	$1.5x10^6$	$1.2x10^6$
		$7.0x10^5$	$4.3x10^5$	$7.0x10^5$	$4.3x10^5$	$7.0x10^5$	$2.4x10^6$	$4.6x10^5$	$9.3x10^5$	$5.0x10^5$
		$2.3x10^5$	$4.3x10^5$	$2.3x10^5$	$4.3x10^5$	$3.3x10^5$	$4.3x10^5$	$2.3x10^5$	$4.3x10^5$	$5.0x10^5$
		$4.6x10^5$	$7.5x10^5$	$4.6x10^5$	$7.5x10^5$	$1.7x10^6$	$7.5x10^5$	$1.1x10^6$	$7.5x10^5$	$9.0x10^5$
		$3.3x10^5$	$4.3x10^5$	$1.7x10^5$	$4.3x10^5$	$4.6x10^5$	$7.5x10^5$	$2.1x10^5$	$7.5x10^5$	$7.0x10^5$
		$7.9x10^5$	$9.3x10^5$	$7.9x10^5$	$9.3x10^5$	$1.3x10^6$	$9.3x10^5$	$1.3x10^6$	$9.3x10^5$	$4.0.10^5$
		$4.9x10^5$	$4.3x10^5$	$4.9x10^5$	$4.3x10^5$	$4.9x10^5$	$4.3x10^5$	$4.9x10^5$	$4.3x10^5$	$9.0x10^5$
		$1.3x10^6$	$9.3x10^5$	$7.9x10^5$	$9.3x10^5$	$1.3x10^6$	$2.4x10^6$	$7.9x10^5$	$2.4x10^6$	$1.0x10^6$
		$3.3x10^5$	$9.3x10^5$	$2.3x10^5$	$4.3x10^5$	$7.9x10^5$	$2.4x10^6$	$4.9x10^5$	$9.3x10^5$	$1.1x10^6$
		$1.3x10^6$	$1.5x10^6$	$1.3x10^6$	$1.5x10^6$	$1.3x10^5$	$1.5x10^6$	$1.3x10^6$	$1.5x10^6$	$1.0x10^6$
Arithmetic Mean		$6.4x10^5$	$7.7x10^5$	$5.5x10^5$	$7.2x10^5$	$8.7x10^5$	$1.3x10^6$	$7.0x10^5$	$1.1x10^6$	$8.2x10^5$
Geometric Mean		$5.5x10^5$	$7.0x10^5$	$4.6x10^5$	$5.2x10^5$	$7.7x10^5$	$1.1x10^6$	$5.5x10^5$	$9.2x10^5$	$7.7x10^5$

Table 6K. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr		LTB 48 hr BGB 48 hr		
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	
May 16, 1978 Primary Effluent South End Pollution Control Centre	10^{-4}	$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$5.6x10^6$
		$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$6.2x10^6$
		$5.4x10^6$	$4.6x10^6$	$5.4x10^6$	$4.6x10^6$	$9.2x10^6$	$1.1x10^7$	$5.4x10^6$	$1.1x10^7$	$6.4x10^6$
		$1.6x10^7$	$4.6x10^6$	$1.6x10^7$	$4.6x10^6$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$8.2x10^6$
		$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$7.0x10^6$
		$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$6.2x10^6$
Arithmetic Mean		$1.1x10^7$	$7.8x10^6$	$1.1x10^7$	$7.8x10^6$	$1.3x10^7$	$1.1x10^7$	$1.1x10^7$	$1.1x10^7$	$6.6x10^6$
Geometric Mean		$1.0x10^7$	$7.1x10^6$	$1.0x10^7$	$7.1x10^6$	$1.2x10^5$	$1.1x10^7$	$1.0x10^7$	$1.1x10^7$	$6.6x10^6$

Table 6L. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr		LTB 48 hr BGB 48 hr		
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	
May 23, 1978 Final Effluent South End Pollution Control Centre	10^{-4}	$4.9x10^5$	$4.3x10^5$	$4.9x10^5$	$4.3x10^5$	$4.9x10^5$	$9.3x10^5$	$4.9x10^5$	$9.3x10^5$	$1.7x10^6$
		$7.9x10^5$	$9.3x10^5$	$7.9x10^5$	$9.3x10^5$	$4.9x10^5$	$9.3x10^5$	$4.9x10^5$	$9.3x10^5$	$1.2x10^6$
		$7.9x10^5$	$4.3x10^5$	$7.9x10^5$	$4.3x10^5$	$7.9x10^5$	$4.3x10^5$	$7.9x10^5$	$4.3x10^5$	$1.5x10^6$
		$4.9x10^5$	$4.3x10^5$	$4.9x10^5$	$4.3x10^5$	$4.9x10^5$	$4.3x10^5$	$4.9x10^5$	$4.3x10^5$	$1.6x10^6$
		$1.1x10^6$	$9.3x10^5$	$7.9x10^5$	$9.3x10^5$	$1.1x10^5$	$9.3x10^5$	$7.9x10^5$	$9.3x10^5$	$1.2x10^6$
		$4.9x10^5$	$9.3x10^5$	$4.9x10^5$	$9.3x10^5$	$1.3x10^6$	$9.3x10^5$	$4.9x10^5$	$9.3x10^5$	$1.5x10^6$
		$7.9x10^5$	$4.3x10^5$	$7.9x10^5$	$4.3x10^5$	$7.9x10^5$	$9.3x10^5$	$7.9x10^5$	$9.3x10^5$	$2.0x10^6$
		$4.9x10^5$	$2.3x10^5$	$4.9x10^5$	$2.3x10^5$	$4.9x10^5$	$2.3x10^5$	$4.9x10^5$	$2.3x10^5$	$1.4x10^6$
		$1.3x10^6$	$9.3x10^5$	$1.3x10^6$	$9.3x10^5$	$1.3x10^6$	$2.4x10^6$	$1.3x10^6$	$9.3x10^5$	$1.3x10^6$
		$7.9x10^5$	$9.3x10^5$	$7.9x10^5$	$9.3x10^5$	$7.9x10^5$	$9.3x10^5$	$7.9x10^5$	$9.3x10^5$	$1.6x10^6$
Arithmetic Mean		$7.5x10^5$	$6.6x10^5$	$7.2x10^5$	$6.6x10^5$	$7.0x10^5$	$9.1x10^5$	$6.9x10^5$	$7.6x10^5$	$1.5x10^6$
Geometric Mean		$7.0x10^5$	$6.2x10^5$	$5.5x10^5$	$5.9x10^5$	$5.9x10^5$	$7.6x10^5$	$6.5x10^5$	$6.9x10^5$	$1.5x10^6$

Table 6M. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr		LTB 48 hr BGB 48 hr		
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	
June 13, 1978 Primary Effluent South End Pollution Control Centre	10^{-4}	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$4.8x10^6$
		$9.2x10^6$	$1.1x10^7$	$5.4x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$5.4x10^6$	$1.1x10^7$	$4.1x10^6$
		$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$1.1x10^7$	$5.4x10^6$	$1.1x10^7$	$5.4x10^6$
		$9.2x10^6$	$1.1x10^7$	$2.8x10^6$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$6.7x10^6$
		$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$4.6x10^6$	$1.6x10^7$	$4.6x10^6$	$1.6x10^7$	$4.6x10^6$	$7.2x10^6$
		$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$4.6x10^6$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$4.6x10^6$	$7.7x10^6$
		$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$4.9x10^6$
		$1.6x10^7$	$4.6x10^6$	$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$4.6x10^6$	$7.0x10^6$
		$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$5.7x10^6$
		$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$4.6x10^6$	$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$4.6x10^6$	$5.1x10^6$
Arithmetic Mean		$1.2x10^7$	$9.1x10^6$	$8.9x10^6$	$7.8x10^6$	$1.4x10^7$	$9.7x10^6$	$1.2x10^7$	$8.4x10^6$	$5.9x10^6$
Geometric Mean		$1.1x10^7$	$8.5x10^6$	$8.2x10^6$	$7.1x10^6$	$1.3x10^7$	$9.2x10^6$	$1.1x10^7$	$7.8x10^6$	$5.7x10^6$

Table 6N. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr		LTB 48 hr BGB 48 hr		
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	
June 19, 1978 Final Effluent South End Pollution Control Centre	10^{-4}	$4.9x10^5$	$4.3x10^5$	$4.9x10^5$	$4.3x10^5$	$4.9x10^5$	$4.3x10^5$	$4.9x10^5$	$4.3x10^5$	$7.0x10^5$
		$4.9x10^5$	$9.3x10^5$	$4.6x10^5$	$4.3x10^5$	$1.3x10^6$	$9.3x10^5$	$4.9x10^5$	$4.3x10^5$	$1.2x10^6$
		$3.3x10^5$	$2.3x10^5$	$3.3x10^5$	$2.3x10^5$	$4.9x10^5$	$2.3x10^5$	$3.3x10^5$	$2.3x10^5$	$4.0x10^5$
		$3.3x10^5$	$2.3x10^5$	$3.3x10^5$	$2.3x10^5$	$3.3x10^5$	$2.3x10^5$	$3.3x10^5$	$2.3x10^5$	$6.0x10^5$
		$7.9x10^5$	$9.3x10^5$	$7.9x10^5$	$2.1x10^5$	$7.9x10^5$	$9.3x10^5$	$7.9x10^5$	$2.1x10^5$	$8.0x10^5$
		$3.3x10^5$	$4.3x10^5$	$3.3x10^5$	$1.5x10^5$	$3.3x10^5$	$4.3x10^5$	$3.3x10^5$	$1.5x10^5$	$6.0x10^5$
		$3.3x10^5$	$4.3x10^5$	$3.3x10^5$	$4.3x10^5$	$3.3x10^5$	$4.3x10^5$	$3.3x10^5$	$4.3x10^5$	$5.0x10^5$
		$7.9x10^5$	$7.5x10^5$	$4.9x10^5$	$7.5x10^5$	$7.9x10^5$	$7.5x10^5$	$4.9x10^5$	$7.5x10^5$	$9.0x10^5$
		$4.9x10^5$	$4.3x10^5$	$3.3x10^5$	$2.3x10^5$	$7.9x10^5$	$7.5x10^5$	$4.9x10^5$	$4.3x10^5$	$1.0x10^6$
		$4.9x10^5$	$2.3x10^5$	$4.9x10^5$	$2.3x10^5$	$4.9x10^5$	$4.3x10^5$	$4.9x10^5$	$4.3x10^5$	$6.0x10^5$
Arithmetic Mean		$4.9x10^5$	$5.0x10^5$	$4.4x10^5$	$3.3x10^5$	$6.1x10^5$	$5.5x10^5$	$4.6x10^5$	$3.77x10^5$	$7.3x10^5$
Geometric Mean		$4.6x10^5$	$4.4x10^5$	$4.2x10^5$	$3.0x10^5$	$5.5x10^5$	$4.9x10^5$	$4.5x10^5$	$3.4x10^5$	$6.9x10^5$

Table 60. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr		LTB 48 hr BGB 48 hr		
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	
June 26, 1978										
Primary Effluent South End Pollution Control Centre	10^{-4}	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$9.8x10^6$
		$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$1.1x10^7$
		$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$9.7x10^6$
		$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$8.4x10^6$
		$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$4.6x10^6$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$9.5x10^6$
		$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$1.1x10^7$
		$1.6x10^7$	$4.6x10^6$	$1.6x10^7$	$4.6x10^6$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.1x10^7$
		$9.2x10^6$	$1.1x10^7$	$5.4x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$1.0x10^7$
		$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$9.5x10^6$
		$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$4.6x10^6$	$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$4.6x10^6$	$8.5x10^6$
Arithmetic Mean		$1.3x10^7$	$1.0x10^7$	$1.2x10^7$	$9.1x10^6$	$1.4x10^7$	$1.1x10^7$	$1.3x10^7$	$1.0x10^7$	$9.9x10^6$
Geometric Mean		$1.3x10^7$	$1.0x10^7$	$1.2x10^7$	$8.5x10^6$	$1.4x10^7$	$1.1x10^7$	$1.2x10^7$	$1.0x10^7$	$9.8x10^6$

Table 6P. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr		LTB 48 hr BGB 48 hr		
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	
July 17, 1978										
Primary Effluent South End Pollution Control Centre	10^{-4}	$1.6x10^7$	$4.6x10^6$	$1.6x10^7$	$4.6x10^6$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.3x10^7$
		$9.2x10^6$	$4.6x10^6$	$5.4x10^6$	$4.6x10^6$	$9.2x10^6$	$1.1x10^7$	$5.4x10^6$	$1.1x10^7$	$1.3x10^7$
		$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.3x10^7$
		$1.6x10^7$	$1.1x10^7$	$5.4x10^6$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$5.4x10^6$	$1.1x10^7$	$1.2x10^7$
		$9.2x10^6$	$2.4x10^6$	$2.2x10^6$	$2.4x10^6$	$9.2x10^6$	$4.6x10^6$	$2.2x10^6$	$4.6x10^6$	$1.3x10^7$
		$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$3.5x10^6$	$1.1x10^7$	$1.3x10^7$
		$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.1x10^7$
		$9.2x10^6$	$1.1x10^7$	$5.4x10^6$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.4x10^7$
		$1.6x10^7$	$4.6x10^6$	$9.2x10^6$	$2.4x10^6$	$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$4.6x10^6$	$1.4x10^7$
		$4.6x10^6$	$1.1x10^7$	$9.2x10^6$	$4.6x10^6$	$1.1x10^7$	$9.2x10^6$	$9.2x10^6$	$1.6x10^7$	$1.2x10^7$
Arithmetic Mean		$1.3x10^7$	$8.2x10^6$	$1.0x10^7$	$7.4x10^6$	$1.4x10^7$	$1.0x10^7$	$9.9x10^6$	$1.9x10^7$	$1.3x10^7$
Geometric Mean		$1.2x10^7$	$7.3x10^6$	$8.5x10^6$	$6.3x10^6$	$1.4x10^7$	$9.9x10^6$	$8.1x10^6$	$9.6x10^6$	$1.3x10^7$

Table 6Q. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr		LTB 48 hr BGB 48 hr		
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	
August 22, 1978 Primary Effluent South End Pollution Control Centre	10^{-4}	$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$1.4x10^7$
		$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$1.5x10^7$
		$5.4x10^6$	$4.6x10^6$	$5.4x10^6$	$4.6x10^6$	$5.4x10^6$	$4.6x10^6$	$5.4x10^6$	$4.6x10^6$	$1.4x10^7$
		$5.4x10^6$	$1.1x10^7$	$5.4x10^6$	$1.1x10^7$	$5.4x10^6$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.3x10^7$
		$9.2x10^6$	$1.1x10^7$	$5.4x10^6$	$4.6x10^6$	$9.2x10^6$	$1.1x10^7$	$5.4x10^6$	$4.6x10^6$	$1.3x10^7$
		$1.6x10^7$	$1.1x10^7$	$5.4x10^6$	$4.6x10^6$	$9.2x10^6$	$1.1x10^7$	$5.4x10^6$	$4.6x10^6$	$1.2x10^7$
		$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$1.2x10^7$
		$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$4.6x10^6$	$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$4.6x10^6$	$1.4x10^7$
		$5.4x10^6$	$1.1x10^7$	$5.4x10^6$	$4.6x10^6$	$5.4x10^6$	$1.1x10^7$	$5.4x10^6$	$4.6x10^6$	$1.5x10^7$
		$1.6x10^7$	$1.1x10^7$	$1.1x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.4x10^7$
Arithmetic Mean		$9.2x10^6$	$9.2x10^6$	$7.5x10^6$	$7.2x10^6$	$1.0x10^7$	$1.0x10^7$	$9.9x10^6$	$7.8x10^6$	$1.3x10^7$
Geometric Mean		$9.8x10^6$	$9.2x10^6$	$7.1x10^6$	$6.5x10^6$	$9.3x10^6$	$1.0x10^7$	$8.3x10^6$	$7.1x10^6$	$1.3x10^7$

Table 6R. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr		LTB 48 hr BGB 48 hr		
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	
August 29, 1978 Primary Effluent South End Pollution Control Centre	10^{-4}	$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.1x10^6$
		$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$1.1x10^7$
		$5.4x10^6$	$4.6x10^6$	$5.4x10^6$	$4.6x10^6$	$5.4x10^6$	$4.6x10^6$	$5.4x10^6$	$4.6x10^6$	$1.1x10^7$
		$5.4x10^6$	$1.1x10^7$	$5.4x10^6$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$9.2x10^6$
		$9.2x10^6$	$1.1x10^7$	$5.4x10^6$	$4.6x10^6$	$9.2x10^6$	$1.1x10^7$	$5.4x10^6$	$4.6x10^6$	$1.0x10^7$
		$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$4.6x10^6$	$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$4.6x10^6$	$8.8x10^6$
		$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.6x10^6$
		$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$4.6x10^6$	$1.6x10^7$	$1.1x10^7$	$9.2x10^6$	$4.6x10^6$	$1.3x10^7$
		$5.4x10^6$	$1.1x10^7$	$5.4x10^6$	$4.6x10^6$	$5.4x10^6$	$1.1x10^7$	$5.4x10^6$	$4.6x10^6$	$9.8x10^6$
		$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.1x10^7$
Arithmetic Mean		$1.1x10^7$	$9.7x10^6$	$8.4x10^6$	$7.2x10^6$	$1.2x10^7$	$1.0x10^7$	$9.4x10^6$	$7.8x10^6$	$1.0x10^7$
Geometric Mean		$1.0x10^7$	$9.2x10^6$	$7.9x10^6$	$6.5x10^6$	$1.1x10^7$	$1.0x10^7$	$8.8x10^6$	$7.1x10^6$	$1.0x10^7$

Table 6S. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr		LTB 48 hr BGB 48 hr		
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	
September 11, 1978 Final Effluent South End Pollution Control Centre	10^{-4}	$2.2x10^5$	$2.3x10^5$	$1.7x10^5$	$2.3x10^5$	$2.2x10^5$	$2.3x10^5$	$1.7x10^5$	$2.3x10^5$	$2.0x10^5$
		$1.3x10^5$	$3.9x10^5$	$1.3x10^5$	$9.0x10^4$	$1.3x10^5$	$3.9x10^5$	$1.3x10^5$	$2.3x10^5$	$2.0x10^5$
		$8.0x10^4$	$9.0x10^4$	$8.0x10^4$	$9.0x10^4$	$1.3x10^5$	$9.0x10^4$	$8.0x10^4$	$9.0x10^4$	$3.0x10^5$
		$5.0x10^4$	$2.3x10^5$	$8.0x10^4$	$2.3x10^5$	$1.7x10^5$	$4.3x10^5$	$8.0x10^4$	$2.3x10^5$	$2.0x10^5$
		$1.7x10^5$	$9.0x10^4$	$1.3x10^5$	$9.0x10^4$	$1.7x10^5$	$9.0x10^4$	$1.7x10^5$	$9.0x10^4$	$3.0x10^5$
		$5.0x10^4$	$2.3x10^5$	$5.0x10^4$	$9.0x10^4$	$8.0x10^4$	$2.3x10^5$	$5.0x10^4$	$9.0x10^4$	$4.0x10^5$
		$1.7x10^5$	$1.5x10^4$	$1.1x10^5$	$1.5x10^5$	$3.3x10^5$	$1.5x10^5$	$1.1x10^5$	$1.5x10^5$	$1.0x10^5$
		$2.3x10^5$	$4.3x10^3$	$2.3x10^5$	$2.3x10^5$	$2.3x10^5$	$4.3x10^5$	$2.3x10^5$	$2.3x10^5$	$1.0x10^5$
		$1.1x10^5$	$9.0x10^4$	$4.3x10^5$	$9.0x10^4$	$3.3x10^5$	$2.3x10^5$	$1.7x10^5$	$9.0x10^4$	$3.0x10^5$
		$1.7x10^5$	$4.3x10^5$	$1.1x10^5$	$9.0x10^4$	$4.9x10^5$	$4.3x10^5$	$1.4x10^5$	$1.7x10^5$	$2.0x10^5$
Arithmetic Mean		$1.4x10^5$	$2.2x10^5$	$1.5x10^5$	$1.4x10^5$	$2.3x10^5$	$2.7x10^5$	$1.3x10^5$	$1.5x10^5$	$2.3x10^5$
Geometric Mean		$1.2x10^5$	$1.6x10^5$	$1.3x10^5$	$1.3x10^5$	$2.0x10^5$	$2.3x10^5$	$1.2x10^5$	$1.5x10^5$	$2.1x10^5$

Table 6T. The precision of the MPN vs MF methodologies (values expressed as coliforms/100 mL sample).

DATE SOURCE	MPN DILUTION	MPN								MF
		LTB 24 hr.		LTB 24hr BGB 48hr		LTB 48 hr		LTB 48 hr BGB 48 hr		
		5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	5:5:5	3:3:3	
September 18, 1978 Primary Effluent South End Pollution Control Centre	10^{-4}	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	
		$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.2x10^7$
		$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.3x10^7$
		$9.2x10^6$	$4.6x10^6$	$5.4x10^6$	$2.4x10^6$	$9.2x10^6$	$4.6x10^6$	$5.4x10^6$	$2.4x10^6$	$1.9x10^7$
		$9.2x10^6$	$2.1x10^6$	$9.2x10^6$	$2.1x10^6$	$9.2x10^6$	$1.6x10^7$	$9.2x10^6$	$1.1x10^7$	$2.1x10^7$
		$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$1.8x10^7$
		$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$4.6x10^6$	$9.2x10^6$	$4.6x10^6$	$1.8x10^7$
		$1.6x10^7$	$4.6x10^6$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$1.1x10^7$	$1.6x10^7$	$4.6x10^6$	$2.1x10^7$
		$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$9.2x10^6$	$1.1x10^7$	$2.2x10^7$
		$5.4x10^6$	$1.1x10^7$	$5.4x10^6$	$4.6x10^6$	$5.4x10^6$	$1.1x10^7$	$5.4x10^6$	$4.6x10^6$	$2.4x10^7$
Arithmetic Mean		$1.4x10^7$	$8.2x10^6$	$1.0x10^7$	$8.0x10^6$	$1.4x10^7$	$1.0x10^7$	$1.0x10^7$	$8.2x10^6$	$1.9x10^7$
Geometric Mean		$1.0x10^7$	$7.2x10^6$	$8.0x10^7$	$6.7x10^6$	$1.0x10^7$	$9.6x10^6$	$9.8x10^6$	$6.9x10^6$	$1.8x10^7$

Table 7. Statistical summation of data presented in Table 6.

Samples	No. Replicates 5:5:5	3:3:3	PORT	LARG	Geometric Mean Values (Coliform counts /100 ml samples) 5:5:5	3:3:3	PORT	LARG	F Values	d.f.	Successive Ranking of Experimental Variables. Variables with no Sig. Differences within Brackets
(a) Aug 22/77 Red River	10	10	10	10	4600	4200	6700	6700	3.96	3,36	(LARG PORT) (5:5:5 3:3:3)
(b) Aug 24/77 Red River	10	10	10	10	8400	4600	5700	5400	3.27	3,36	(5:5:5 PORT)(PORT LARG 3:3:3)
(c) Aug 29/77 Assiniboine River	10	10	10	10	9600	7500	12000	10000	1.29	3,36	(PORT LARG 5:5:5 3:3:3)
(d) March 28/78 Prim. effl. SEPCC	5	5	5	-	3500000	6800000	4700000	-	0.87	2,12	(3:3:3 PORT 5:5:5)
(e) April 17/78 Prim. effl. SEPCC	9	9	9	-	4000000	3000000	4800000	-	1.78	2,24	(PORT 5:5:5 3:3:3)
(f) April 24/78 Final effl. SEPCC	4	4	4	-	71000	69000	180000	-	6.43	2,09	(PORT) (5:5:5 3:3:3)
(g) April 24/78 Prim. effl. SEPCC	5	5	5	-	12000000	45000000	9800000	-	4.11	2,12	(5:5:5 PORT) (3:3:3)
(h) May 1/78 Final effl. SEPCC	5	5	5	-	390000	280000	710000	-	6.23	2,12	(PORT) (5.5:5 3.3:3)
(i) May 1/78 Prim. effl. SEPCC	5	5	5	-	3200000	5700000	5100000	-	0.98	2,12	(3:3:3 PORT 5:5:5)
(j) May 8/78 Final effl. SEPCC	10	10	10	-	550000	920000	770000	-	2.30	2,27	(3:3:3 PORT 5:5:5)
(k) May 10/78 Prim. effl. SEPCC	6	6	6	-	10000000	11000000	6600	-	7.52	2,15	(3:3:3 5:5:5) (PORT)
(l) May 23/78 Prim. effl. SEPCC	10	10	10	-	650000	690000	1500000	-	15.91	2,27	(PORT) (3:3:3 5:5:5)
(m) June 13/78 Final effl. SEPCC	10	10	10	-	11000000	7800000	5700000	-	6.89	2,27	(5:5:5 3:3:3)(3:3:3 PORT)
(n) June 19/78 Final effl. SEPCC	10	10	10	-	440000	340000	690000	-	9.49	2,27	(PORT) (5:5:5 3:3:3)
(o) June 26/78 Prim. effl. SEPCC	10	10	10	-	12000000	10000000	9800000	-	2.35	2,27	(5:5:5 3:3:3 PORT)

Table 7. continued.

Samples	No. Replicates 5:5:5	3:3:3	PORT	LARG	Geometric Mean Values (Coliform counts /100 ml samples) 5:5:5	3:3:3	PORT	LARG	F Values	d.f.	Successive Ranking of Experimental Variables. Variables with no Sig. Differences within Brackets
(p) July 17/78 Prim. effl. SEPCC	10	10	10	-	8100000	9600000	13000000	-	2.20	2,27	(PORT 3:3:3 5:5:5)
(q) Aug 22/78 Prim. effl. SEPCC	10	10	10	-	8300000	7100000	13000000	-	8.21	2,27	(PORT) (5:5:5 3:3:3)
(r) Aug.29/78 Prim. effl. SEPCC	10	10	10	-	8800000	7100000	10000000	-	2.50	2,27	(PORT 5:5:5)(5:5:5 3:3:3)
(s) Sept 18/78 Prim. effl. SEPCC	10	10	10		120000	150000	210000	-	3.73	2,27	(PORT 3:3:3)(3:3:3 5:5:5)
(t) Sept. 18/78 Prim. effl. SEPCC	10	10	9	-	9800000	690000	1800000	-	11.25	2,26	(PORT) (5:5:5 3:3:3)

Table 8. "Frequency of occurrence" of experimental variables presented in Tables 6 and 7.

	HIGHEST	SECOND	THIRD	LOWEST	TOTAL	DEGREE OF FREEDOM	CHI-SQUARE
5:5:5	4	8	8	-	20	K-1=2	1.60
3:3:3	4	5	8	3	20	K-1=3	2.80
PORT	11	6	3	-	20	K-1=2	4.90
LARGE	1	1	1	-	3	no analysis possible	
TOTAL	20	20	20	3	63		

Table 9A. Enterobacter cloacae API # 3 205 773

Replicates	Dilution 10^7 10^8 10^9 10^{10}	MPN Coliforms/ 100 ml	MF Coliforms/ 100 ml	SPC/ 100 ml	MacConkey/ 100 ml	EMB/ 100 ml
1	5 (5 1 1)	4.6×10^{10}	4.5×10^{10}	5.0×10^{10}	5.3×10^{10}	4.7×10^{10}
2	5 (5 2 0)	4.9×10^{10}	4.8×10^{10}	6.0×10^{10}	5.3×10^{10}	3.9×10^{10}
3	5 (5 3 0)	7.9×10^{10}	5.0×10^{10}	5.0×10^{10}	5.8×10^{10}	4.7×10^{10}
4	5 (5 3 1)	1.1×10^{11}	4.0×10^{10}	5.0×10^{10}	3.7×10^{10}	5.0×10^{10}
5	5 (5 3 1)	1.1×10^{11}	4.3×10^{10}	5.0×10^{10}	4.8×10^{10}	4.2×10^{10}
Geometric Means (counts/100 ml)		7.4×10^{10}	4.5×10^{10}	5.2×10^{10}	4.9×10^{10}	4.5×10^{10}
Arithmetic Means (counts/100 ml)		7.9×10^{10}	4.5×10^{10}	5.2×10^{10}	5.0×10^{10}	4.5×10^{10}

Table 9B. Klebsiella pneumoniae API # 5 215 773

Replicates	Dilution 10^7 10^8 10^9 10^{10}	MPN Coliforms/ 100 ml	MF Coliforms/ 100 ml	SPC/ 100 ml	MacConkey/ 100 ml	EMB/ 100 ml
1	5 (5 3 0)	7.9×10^{10}	7.7×10^{10}	5.3×10^{10}	5.6×10^{10}	2.9×10^{10}
2	5 (5 1 0)	3.3×10^{10}	6.2×10^{10}	4.8×10^{10}	5.2×10^{10}	5.7×10^{10}
3	5 (5 3 0)	7.9×10^{10}	5.3×10^{10}	4.5×10^{10}	4.3×10^{10}	3.4×10^{10}
4	5 (5 1 0)	3.3×10^{10}	6.0×10^{10}	3.8×10^{10}	7.1×10^{10}	7.7×10^{10}
5	5 (5 3 0)	7.9×10^{10}	5.6×10^{10}	7.0×10^{10}	6.3×10^{10}	4.1×10^{10}
6	5 (5 4 1)	1.7×10^{10}	5.8×10^{10}	6.1×10^{10}	6.0×10^{10}	7.3×10^{10}
7	5 (5 1 1)	4.6×10^{10}	5.7×10^{10}	5.0×10^{10}	7.5×10^{10}	5.4×10^{10}
Geometric Means (counts/100 ml)		6.4×10^{10}	6.0×10^{10}	5.1×10^{10}	5.9×10^{10}	4.9×10^{10}
Arithmetic Means (counts/100 ml)		5.2×10^{10}	6.0×10^{10}	5.2×10^{10}	6.0×10^{10}	5.2×10^{10}

Table 9C. E. coli API # 3 144 572

Replicates	Dilution 10^7 10^8 10^9 10^{10}	MPN Coliforms/ 100 ml	MF Coliforms/ 100 ml	SPC/ 100 ml	MacConkey/ 100 ml	EMB/ 100 ml
1	5 (5 2 2)	9.4×10^{10}	8.8×10^{10}	1.2×10^{11}	6.2×10^{10}	1.0×10^{11}
2	5 (5 5 0)	2.4×10^{11}	9.7×10^{10}	1.1×10^{11}	8.4×10^{10}	7.2×10^{10}
3	5 (5 3 0)	7.9×10^{10}	1.1×10^{11}	1.0×10^{11}	1.6×10^{11}	1.0×10^{11}
4	5 (5 3 1)	1.1×10^{11}	9.3×10^{10}	1.0×10^{11}	1.6×10^{11}	7.9×10^{10}
5	5 (5 5 0)	2.4×10^{11}	1.0×10^{11}	1.3×10^{11}	4.1×10^{10}	1.1×10^{11}
6	5 (5 4 0)	1.3×10^{11}	1.0×10^{11}	1.0×10^{11}	1.1×10^{11}	1.1×10^{11}
7	5 (5 5 0)	2.4×10^{11}	1.0×10^{11}	1.0×10^{11}	-	1.1×10^{11}
8	5 (5 4 0)	1.3×10^{11}	1.0×10^{11}	1.0×10^{11}	-	1.2×10^{11}
Geometric Means (counts/100 ml)		1.4×10^{11}	9.8×10^{10}	1.1×10^{10}	9.2×10^{10}	9.9×10^{10}
Arithmetic Means (counts/100 ml)		1.6×10^{10}	9.9×10^{10}	1.1×10^{11}	1.0×10^{11}	1.0×10^{11}

Table 9D. E. coli API # 7 144 573

Replicates	Dilution 10^7 10^8 10^9 10^{10}	MPN Coliforms/ 100 ml	MF Coliforms/ 100 ml	SPC/ 100 ml	MacConkey/ 100 ml	EMB/ 100 ml
1	(5 4 0) 1	1.3×10^{10}	1.9×10^{10}	1.9×10^{10}	1.8×10^{10}	-
2	5 (5 3 0)	7.9×10^{10}	2.6×10^{10}	2.4×10^{10}	-	1.9×10^{10}
3	(5 4 1) 0	1.7×10^{10}	1.6×10^{10}	1.9×10^{10}	-	-
4	5 (5 1 0)	3.3×10^{10}	2.2×10^{10}	2.1×10^{10}	1.4×10^{10}	-
5	(5 4 1) 0	1.7×10^{10}	1.6×10^{10}	1.7×10^{10}	-	1.8×10^{10}
6	(5 4 1) 0	1.7×10^{10}	1.9×10^{10}	1.2×10^{10}	-	2.1×10^{10}
7	(5 3 0) 0	7.9×10^{10}	2.3×10^{10}	1.5×10^{10}	1.7×10^{10}	1.2×10^{10}
8	(5 4 1) 0	1.7×10^{10}	2.3×10^{10}	2.1×10^{10}	-	1.5×10^{10}
9	(5 3 3) 0	1.8×10^{10}	2.0×10^{10}	-	-	1.7×10^{10}
Geometric Means (counts/100 ml)		2.5×10^{10}	2.0×10^{10}	1.8×10^{10}	1.6×10^{10}	1.2×10^{10}
Arithmetic Means (counts/100 ml)		3.2×10^{10}	2.0×10^{10}	1.9×10^{10}	1.6×10^{10}	1.7×10^{10}

Table 9E. E. coli API # 5 146 572

Replicates	Dilution 10^7 10^8 10^9 10^{10}	MPN Coliforms/ 100 ml	MF Coliforms/ 100 ml	SPC/ 100 ml	MacConkey/ 100 ml	EMB/ 100 ml
1	5 (5 5 2)	5.4×10^{11}	1.2×10^{11}	1.2×10^{11}	1.2×10^{11}	1.5×10^{11}
2	5 (5 3 2)	1.4×10^{11}	1.5×10^{11}	1.3×10^{11}	9.3×10^{10}	1.3×10^{11}
3	5 (5 4 0)	1.3×10^{11}	1.4×10^{11}	1.4×10^{11}	5.5×10^{10}	1.4×10^{11}
4	5 (5 5 1)	3.5×10^{11}	1.4×10^{11}	1.6×10^{11}	1.4×10^{11}	1.3×10^{11}
5	5 (5 3 0)	7.9×10^{10}	1.2×10^{11}	1.3×10^{11}	1.4×10^{11}	1.0×10^{11}
6	5 (5 4 0)	1.3×10^{11}	1.4×10^{11}	1.3×10^{11}	1.3×10^{11}	1.4×10^{11}
7	5 (5 4 0)	1.3×10^{11}	1.3×10^{11}	1.2×10^{11}	1.2×10^{11}	1.7×10^{11}
8	5 (5 4 0)	1.3×10^{11}	1.4×10^{11}	1.4×10^{11}	1.4×10^{11}	1.7×10^{11}
Geometric Means (counts/100 ml)		1.7×10^{11}	1.3×10^{11}	1.3×10^{11}	1.1×10^{11}	1.4×10^{11}
Arithmetic Means counts/100 ml)		2.0×10^{11}	1.4×10^{5}	1.3×10^{11}	1.2×10^{11}	1.4×10^{11}

Table 9F. E. coli API # (LDC ODC 1 044 552)

Replicates	Dilution 10^7 10^8 10^9 10^{10}	MPN Coliforms/ 100 ml	MF Coliforms/ 100 ml	SPC/ 100 ml	MacConkey/ 100 ml	EMB/ 100 ml
1	5 (5 3 0)	7.9×10^{10}	1.2×10^{11}	1.0×10^{11}	3.8×10^{10}	1.2×10^{11}
2	5 (5 3 2)	1.4×10^{11}	1.0×10^{11}	1.1×10^{11}	4.2×10^{10}	1.5×10^{11}
3	5 (5 3 2)	1.4×10^{11}	1.2×10^{11}	8.4×10^{10}	3.8×10^{10}	1.4×10^{11}
4	5 (5 1 1)	4.6×10^{10}	1.2×10^{11}	1.0×10^{11}	4.6×10^{10}	1.6×10^{11}
5	5 (5 3 1)	1.1×10^{11}	1.0×10^{11}	1.0×10^{11}	-	9.3×10^{10}
6	5 (5 5 1)	3.5×10^{11}	1.3×10^{11}	1.0×10^{11}	3.0×10^{10}	1.3×10^{11}
7	5 (5 4 0)	1.3×10^{11}	1.2×10^{11}	1.0×10^{11}	5.0×10^{10}	9.1×10^{10}
8	5 (5 3 0)	7.9×10^{10}	1.2×10^{11}	1.2×10^{11}	-	1.5×10^{11}
Geometric Means (counts/100 ml)		1.1×10^{11}	1.2×10^{11}	1.0×10^{11}	4.0×10^{10}	1.3×10^{11}
Arithmetic Means (counts/100 ml)		1.3×10^{11}	1.2×10^{11}	1.0×10^{11}	4.1×10^{10}	1.3×10^{11}

Table 9G. Enterobacter agglomerans API # 1 044 173

Replicates	Dilution 10^7 10^8 10^9 10^{10}	MPN Coliforms/ 100 ml	MF Coliforms/ 100 ml	SPC/ 100 ml	MacConkey/ 100 ml	EMB/ 100 ml
1	5 (5 0 0)	2.3×10^{10}	5.1×10^{10}	5.4×10^{10}	1.6×10^{10}	3.4×10^{10}
2	5 (5 2 0)	4.9×10^{10}	4.4×10^{10}	6.0×10^{10}	-	4.0×10^{10}
3	5 (5 2 0)	4.9×10^{10}	4.0×10^{10}	4.8×10^{10}	-	3.5×10^{10}
4	5 (5 0 0)	2.3×10^{10}	4.7×10^{10}	4.5×10^{10}	1.3×10^{10}	4.4×10^{10}
5	5 (5 3 1)	1.1×10^{11}	4.0×10^{10}	4.1×10^{10}	1.3×10^{10}	4.1×10^{10}
6	5 (5 4 0)	1.3×10^{11}	5.1×10^{10}	4.0×10^{10}	-	3.2×10^{10}
7	5 (5 2 0)	4.9×10^{10}	5.2×10^{10}	4.1×10^{10}	1.8×10^{10}	7.7×10^{10}
8	5 (5 1 0)	3.3×10^{10}	5.2×10^{10}	4.1×10^{10}	2.1×10^{10}	1.6×10^{10}
Geometric Means (counts/100 ml)		4.8×10^{10}	4.7×10^{10}	4.6×10^{10}	1.6×10^{10}	3.7×10^{10}
Arithmetic Means (counts/100 ml)		5.8×10^{10}	4.7×10^{10}	4.6×10^{10}	1.6×10^{10}	4.0×10^{10}

Table 9H. E. coli API # 5 144 572

Replicates	Dilution 10^7 10^8 10^9 10^{10}	MPN Coliforms/ 100 ml	MF Coliforms/ 100 ml	SPC/ 100 ml	MacConkey/ 100 ml	EMB/ 100 ml
1	5 (5 2 0)	4.9×10^{10}	1.1×10^{11}	1.5×10^{11}	1.6×10^{11}	3.4×10^{11}
2	5 (5 4 0)	1.3×10^{11}	1.7×10^{11}	1.3×10^{11}	1.5×10^{11}	4.8×10^{11}
3	5 (5 4 1)	1.7×10^{11}	1.4×10^{11}	1.3×10^{11}	1.7×10^{11}	4.4×10^{11}
4	5 (5 3 1)	1.1×10^{11}	1.5×10^{11}	---	1.4×10^{11}	4.0×10^{11}
5	5 (5 5 1)	3.5×10^{11}	1.9×10^{11}	1.3×10^{11}	1.9×10^{11}	4.5×10^{11}
6	5 (5 4 0)	1.3×10^{11}	1.1×10^{11}	1.4×10^{11}	1.5×10^{11}	3.2×10^{11}
7	5 (5 5 1)	3.5×10^{11}	1.7×10^{11}	1.4×10^{11}	2.0×10^{11}	3.5×10^{11}
8	5 (5 4 1)	1.7×10^{11}	1.2×10^{11}	1.3×10^{11}	1.5×10^{11}	4.0×10^{11}
Geometric Means (counts/100 ml)		1.5×10^{11}	1.4×10^{11}	1.4×10^{11}	1.6×10^{11}	3.9×10^{11}
Arithmetic Means (counts/100 ml)		1.8×10^{11}	1.5×10^{11}	1.4×10^{11}	1.6×10^{11}	4.0×10^{11}

Table 9I. *E. coli* API # 1 44 572

Replicates	Dilution 10^7 10^8 10^9 10^{10}	MPN Coliforms/ 100 ml	MF Coliforms/ 100 ml	SPC/ 100 ml	MacConkey/ 100 ml	EMB/ 100 ml
1	5 (5 5 3)	9.2×10^{11}	1.6×10^{11}	1.6×10^{11}	1.0×10^{11}	1.8×10^{11}
2	5 (5 5 2)	5.4×10^{11}	1.3×10^{11}	1.4×10^{11}	1.6×10^{11}	1.7×10^{11}
3	5 (5 5 3)	9.2×10^{11}	1.4×10^{11}	-	1.2×10^{11}	1.9×10^{11}
4	5 (5 5 2)	5.4×10^{11}	1.2×10^{11}	1.3×10^{11}	2.5×10^{11}	1.8×10^{11}
5	5 (5 5 2)	5.4×10^{11}	1.7×10^{11}	1.2×10^{11}	1.4×10^{11}	1.8×10^{11}
6	5 (5 5 1)	3.5×10^{11}	1.4×10^{11}	1.5×10^{11}	8.6×10^{10}	1.8×10^{11}
7	5 (5 5 3)	9.2×10^{11}	1.4×10^{11}	1.5×10^{11}	1.6×10^{11}	1.8×10^{11}
8	5 (5 5 4)	1.6×10^{12}	1.7×10^{11}	1.5×10^{11}	2.3×10^{11}	1.7×10^{11}
Geometric Means (counts/100 ml)		7.2×10^{11}	1.5×10^{11}	1.4×10^{11}	1.5×10^{11}	1.8×10^{11}
Arithmetic Means (counts/100 ml)		7.9×10^{11}	1.5×10^{11}	1.4×10^{11}	1.6×10^{11}	1.8×10^{11}

Table 9J. *Klebsiella pneumoniae* API # 5 215 773

Replicates	Dilution 10^7 10^8 10^9 10^{10}	MPN Coliforms/ 100 ml	MF Coliforms/ 100 ml	SPC/ 100 ml	MacConkey/ 100 ml	EMB/ 100 ml
1	5 (5 5 2)	5.4×10^{11}	1.6×10^{11}	2.0×10^{11}	1.1×10^{11}	2.0×10^{11}
2	5 (5 3 0)	7.9×10^{10}	1.2×10^{11}	2.0×10^{11}	TNTC	1.9×10^{11}
3	5 (5 3 3)	1.8×10^{11}	1.5×10^{11}	1.8×10^{11}	1.5×10^{11}	1.7×10^{11}
4	5 (5 3 0)	7.9×10^{10}	1.5×10^{11}	1.8×10^{11}	1.5×10^{11}	1.5×10^{11}
5	5 (5 5 1)	3.5×10^{11}	1.7×10^{11}	1.9×10^{11}	TNTC	1.9×10^{11}
6	5 (5 4 0)	1.3×10^{11}	1.5×10^{11}	1.7×10^{11}	2.0×10^{11}	1.8×10^{11}
7	5 (5 5 2)	5.4×10^{11}	1.6×10^{11}	1.9×10^{11}	8.7×10^{10}	1.6×10^{11}
8	5 (5 4 1)	1.7×10^{11}	1.4×10^{11}	1.9×10^{11}	1.4×10^{11}	1.8×10^{11}
Geometric Means (counts/100 ml)		2.0×10^{11}	1.5×10^{11}	1.9×10^{11}	1.3×10^{11}	1.8×10^{11}
Arithmetic Means (counts/100 ml)		2.6×10^{11}	1.5×10^{11}	1.9×10^{11}	1.4×10^{11}	1.8×10^{11}

Table 9K. *E. coli* API # 5 044 572

Replicates	Dilution 10^7 10^8 10^9 10^{10}	MPN Coliforms/ 100 ml	MF Coliforms/ 100 ml	SPC/ 100 ml	MacConkey/ 100 ml	EMB/ 100 ml
1	5 (5 1 0)	3.3×10^{10}	6.1×10^{10}	5.0×10^{10}	2.4×10^{10}	5.2×10^{10}
2	5 (5 3 0)	7.9×10^{10}	5.9×10^{10}	5.2×10^{10}	3.6×10^{10}	4.1×10^{10}
3	5 (5 2 0)	4.9×10^{10}	5.7×10^{10}	5.3×10^{10}	2.0×10^{10}	3.2×10^{10}
4	5 (5 2 1)	7.0×10^{10}	5.0×10^{10}	5.2×10^{10}	-	5.0×10^{10}
5	5 (5 3 1)	1.1×10^{11}	6.3×10^{10}	5.0×10^{10}	2.9×10^{10}	4.1×10^{10}
6	5 (5 2 0)	4.9×10^{10}	5.5×10^{10}	5.0×10^{10}	2.9×10^{10}	8.0×10^{10}
7	5 (5 0 0)	2.3×10^{11}	6.7×10^{10}	5.1×10^{10}	2.0×10^{10}	3.7×10^{10}
8	5 (5 3 0)	7.9×10^{10}	5.5×10^{10}	5.0×10^{10}	3.0×10^{10}	2.7×10^{10}
Geometric Means (counts/100 ml)		7.4×10^{10}	5.8×10^{10}	5.1×10^{10}	2.6×10^{10}	4.3×10^{10}
Arithmetic Means (counts/100 ml)		8.7×10^{10}	5.8×10^{10}	5.1×10^{10}	2.7×10^{10}	4.5×10^{10}

Table 9L. *Enterobacter cloacae* API # 2 305 773

Replicates	Dilution 10^7 10^8 10^9 10^{10}	MPN Coliforms/ 100 ml	MF Coliforms/ 100 ml	SPC/ 100 ml	MacConkey/ 100 ml	EMB/ 100 ml
1	5 (5 1 0)	3.3×10^{10}	4.5×10^{10}	4.9×10^{10}	4.6×10^{10}	5.3×10^{10}
2	5 (5 0 0)	2.3×10^{10}	4.9×10^{10}	5.1×10^{10}	2.7×10^{10}	4.1×10^{10}
3	5 (5 2 0)	4.9×10^{10}	5.2×10^{10}	4.7×10^{10}	2.6×10^{10}	5.6×10^{10}
4	5 (5 1 0)	1.7×10^{10}	5.1×10^{10}	6.2×10^{10}	2.4×10^{10}	3.7×10^{10}
5	5 (5 1 1)	4.6×10^{10}	5.8×10^{10}	6.0×10^{10}	8.0×10^{10}	5.0×10^{10}
6	5 (5 2 0)	4.9×10^{10}	5.7×10^{10}	6.2×10^{10}	5.0×10^{10}	5.0×10^{10}
7	5 (5 2 1)	7.0×10^{10}	5.2×10^{10}	6.3×10^{10}	4.7×10^{10}	TNTC
8	5 (5 1 0)	3.3×10^{10}	5.2×10^{10}	6.8×10^{10}	3.6×10^{10}	TNTC
Geometric Means (counts/100 ml)		3.7×10^{10}	5.2×10^{10}	5.8×10^{10}	4.8×10^{10}	4.7×10^{11}
Arithmetic Means (counts/100 ml)		4.0×10^{10}	5.2×10^{10}	5.8×10^{10}	4.2×10^{10}	4.8×10^{10}

Table 9M. Klebsiellae pneumoniae API # 1 205 773

Replicates	Dilution 10^7 10^8 10^9 10^{10}	MPN Coliforms/ 100 ml	MF Coliforms/ 100 ml	SPC/ 100 ml	MacConkey/ 100 ml	EMB/ 100 ml
1	5 (5 1 0)	3.3×10^{10}	2.7×10^{10}	3.6×10^{10}	3.8×10^{10}	5.1×10^{10}
2	5 (5 1 1)	4.6×10^{10}	3.8×10^{10}	3.2×10^{10}	5.0×10^{10}	3.8×10^{10}
3	5 (5 2 0)	4.9×10^{10}	4.2×10^{10}	3.5×10^{10}	5.1×10^{10}	5.0×10^{10}
4	5 (5 2 0)	4.9×10^{10}	3.5×10^{10}	3.2×10^{10}	4.8×10^{10}	3.0×10^{10}
5	5 (5 1 0)	3.3×10^{10}	3.0×10^{10}	3.5×10^{10}	4.6×10^{10}	5.0×10^{10}
6	5 (5 2 0)	4.9×10^{10}	2.4×10^{10}	2.1×10^{10}	4.5×10^{10}	5.0×10^{10}
7	5 (5 1 0)	3.3×10^{10}	3.2×10^{10}	3.1×10^{10}	3.8×10^{10}	6.0×10^{10}
8	5 (5 1 1)	4.6×10^{10}	3.3×10^{10}	2.8×10^{10}	5.0×10^{10}	5.0×10^{10}
Geometric Means (counts/100 ml)		4.2×10^{10}	3.2×10^{10}	3.1×10^{10}	4.5×10^{10}	4.6×10^{10}
Arithmetic Means (counts/100 ml)		4.2×10^{10}	3.3×10^{10}	3.1×10^{10}	4.6×10^{10}	4.7×10^{10}

Table 9N. E. coli API # 5 144 552

Replicates	Dilution 10^7 10^8 10^9 10^{10}	MPN Coliforms/ 100 ml	MF Coliforms/ 100 ml	SPC/ 100 ml	MacConkey/ 100 ml	EMB/ 100 ml
1	5 (5 4 1)	1.7×10^{11}	7.2×10^{10}	5.8×10^{10}	5.2×10^{10}	TNTC
2	5 (5 2 1)	7.0×10^{10}	7.0×10^{10}	7.4×10^{10}	3.3×10^{10}	TNTC
3	5 (5 3 0)	7.9×10^{10}	7.8×10^{10}	8.0×10^{10}	5.6×10^{10}	6.8×10^{10}
4	5 (5 3 2)	1.4×10^{11}	9.3×10^{10}	7.7×10^{10}	4.0×10^{10}	1.0×10^{11}
5	5 (5 2 0)	4.9×10^{10}	7.8×10^{10}	6.2×10^{10}	3.8×10^{10}	1.0×10^{11}
6	5 (5 1 1)	4.6×10^{10}	8.5×10^{10}	7.4×10^{10}	6.0×10^{10}	9.5×10^{10}
7	5 (5 5 0)	2.4×10^{11}	6.7×10^{10}	6.7×10^{10}	3.2×10^{10}	9.4×10^{10}
8	5 (5 4 1)	1.7×10^{11}	5.6×10^{10}	5.6×10^{10}	6.5×10^{10}	9.6×10^{10}
Geometric Means (counts/100 ml)		1.0×10^{11}	7.4×10^{10}	6.8×10^{10}	4.5×10^{10}	9.1×10^{10}
Arithmetic Means (counts/100 ml)		1.2×10^{11}	7.5×10^{10}	6.9×10^{10}	4.7×10^{10}	9.2×10^{10}

Table 90. Klebsiellae pneumoniae API # 1 215 773

Replicates	Dilution 10^7 10^8 10^9 10^{10}	MPN Coliforms/ 100 ml	MF Coliforms/ 100 ml	SPC/ 100 ml	MacConkey/ 100 ml	EMB/ 100 ml
1	5 (5 5 1)	3.5×10^{11}	1.7×10^{11}	1.6×10^{11}	2.0×10^{11}	1.2×10^{11}
2	5 (5 4 1)	1.7×10^{11}	1.7×10^{11}	1.7×10^{11}	8.3×10^{10}	2.0×10^{11}
3	5 (5 4 0)	1.3×10^{11}	1.4×10^{11}	2.0×10^{11}	1.7×10^{11}	1.9×10^{11}
4	5 (5 4 0)	1.3×10^{11}	1.6×10^{11}	1.9×10^{11}	1.7×10^{11}	2.0×10^{11}
5	5 (5 4 1)	1.7×10^{11}	1.6×10^{11}	1.7×10^{11}	1.0×10^{11}	2.3×10^{11}
6	5 (5 4 0)	1.3×10^{11}	1.5×10^{11}	1.7×10^{11}	1.9×10^{11}	2.2×10^{11}
7	5 (5 5 0)	2.4×10^{11}	1.6×10^{11}	1.7×10^{11}	1.5×10^{11}	1.2×10^{11}
8	5 (5 5 2)	5.4×10^{11}	1.6×10^{11}	1.7×10^{11}	1.7×10^{11}	1.5×10^{11}
Geometric Means (counts/100 ml)		2.0×10^{11}	1.6×10^{11}	1.7×10^{11}	1.5×10^{11}	1.7×10^{11}
Arithmetic Means (counts/100 ml)		2.3×10^{11}	1.6×10^{11}	1.8×10^{11}	1.5×10^{11}	1.8×10^{11}

Table 9P. C. freundii API # 1 404 573

Replicates	Dilution 10^7 10^8 10^9 10^{10}	MPN Coliforms/ 100 ml	MF Coliforms/ 100 ml	SPC/ 100 ml	MacConkey/ 100 ml	EMB/ 100 ml
1	5 (5 0 0)	2.3×10^{10}	8.7×10^{10}	8.6×10^{10}	8.2×10^{10}	1.0×10^{11}
2	5 (5 4 0)	1.3×10^{11}	8.9×10^{10}	9.1×10^{10}	8.3×10^{10}	1.1×10^{11}
3	5 (5 3 0)	7.9×10^{10}	7.2×10^{10}	8.7×10^{10}	1.4×10^{11}	1.2×10^{11}
4	5 (5 3 0)	7.9×10^{10}	9.5×10^{10}	9.3×10^{10}	5.7×10^{10}	1.0×10^{11}
5	5 (5 2 0)	4.9×10^{10}	9.7×10^{10}	8.2×10^{10}	1.2×10^{11}	8.8×10^{10}
6	5 (5 2 0)	4.9×10^{10}	7.7×10^{10}	1.0×10^{11}	5.0×10^{10}	9.7×10^{10}
7	5 (5 4 0)	1.3×10^{11}	8.9×10^{10}	1.0×10^{11}	1.0×10^{11}	7.7×10^{10}
8	5 (5 3 2)	1.4×10^{11}	9.7×10^{10}	1.0×10^{11}	9.7×10^{10}	-
Geometric Means (counts/100 ml)		7.3×10^{10}	8.7×10^{10}	9.2×10^{10}	8.7×10^{10}	9.8×10^{10}
Arithmetic Means (counts/100 ml)		8.5×10^{10}	8.8×10^{10}	9.2×10^{10}	9.1×10^{10}	9.9×10^{10}

Table 10. Statistical summation of data presented in Table 9.

TABLE	STRAIN	No. Replicates MPN	SPC	MAC	MF	EMB	Geometric Mean Values MPN	SPC	MAC	MF	EMB	F Values	d.f.	Successive Ranking of Experimental Variables [Variables with no Sig. Differences within Brackets]
10 (A)	E. cloacae 3 205 773	5	5	5	5	5	$7.4x10^{10}$	$5.2x10^{10}$	$4.9x10^{10}$	$4.5x10^{10}$	$4.5x10^{10}$	4.45	4,20	(MPN)(SPC MAC MF EMB)
(B)	K. pneumoniae 5 215 773	7	7	7	7	7	$6.4x10^{10}$	$5.1x10^{10}$	$5.9x10^{10}$	$6.0x10^{10}$	$4.9x10^{10}$	0.73	4,30	(MPN MF MAC SPC EMB)
(C)	E. coli 3 144 572	8	8	6	8	8	$1.4x10^{11}$	$1.1x10^{11}$	$9.2x10^{10}$	$9.8x10^{10}$	$9.9x10^{10}$	2.50	4,33	(MPN SPC)(SPC EMB MF MAC)
(D)	E. coli 7 144 573	9	8	3	9	6	$2.5x10^{10}$	$1.8x10^{10}$	$1.6x10^{10}$	$2.0x10^{10}$	$1.7x10^{10}$	1.40	4,30	(MPN MF SPC EMB MAC)
(E)	E. coli 5 146 572	8	8	8	8	8	$1.7x10^{11}$	$1.3x10^{11}$	$1.1x10^{11}$	$1.3x10^{11}$	$1.4x10^{11}$	1.45	4,35	(MPN EMB MF SPC) (EMB MF SPC MAC)
(F)	E. coli 1 044 552	8	8	6	8	8	$1.1x10^{11}$	$1.0x10^{11}$	$4.0x10^{11}$	$1.2x10^{11}$	$1.3x10^{11}$	15.31	4,33	(EMB MF MPN SPC)(MAC)
(G)	E. agglomerans 1 044 173	8	8	5	8	8	$4.8x10^{10}$	$4.6x10^{10}$	$1.6x10^{10}$	$4.7x10^{10}$	$3.7x10^{10}$	8.39	4,32	(MPN MF SPC EMB)(MAC)
(H)	E. coli 5 144 572	8	7	8	8	8	$1.5x10^{11}$	$1.4x10^{11}$	$1.6x10^{11}$	$1.4x10^{11}$	$3.0x10^{10}$	15.27	4,34	(EMB)(MAC MPN MF SPC)
(I)	E. coli 1 144 572	8	7	8	8	8	$7.2x10^{11}$	$1.4x10^{11}$	$1.5x10^{11}$	$1.5x10^{11}$	$1.8x10^{11}$	47.78	4,34	(MPN)(EMB MAC MF SPC)
(J)	K. pneumoniae 5 215 773	8	8	6	8	8	$2.0x10^{11}$	$1.9x10^{11}$	$1.3x10^{11}$	$1.5x10^{11}$	$1.8x10^{11}$	1.29	4,33	(MPN SPC EMB MF MAC)
(K)	E. coli 5 044 572	8	8	7	8	8	$7.4x10^{11}$	$5.1x10^{10}$	$2.6x10^{10}$	$5.8x10^{10}$	$4.3x10^{10}$	10.54	4,34	(MPN MF)(MF SPC EMB) (MAC)
(L)	E. cloacae 2 305 773	8	8	8	8	6	$3.7x10^{10}$	$5.8x10^{10}$	$4.8x10^{10}$	$5.2x10^{10}$	$4.7x10^{10}$	3.13	4,33	(SPC MF MAC EMB) (MAC EMB MPN)
(M)	K. pneumoniae 1 205 773	8	8	8	8	8	$4.2x10^{10}$	$3.1x10^{10}$	$4.5x10^{10}$	$3.2x10^{10}$	$4.6x10^{10}$	9.29	4,35	(EMB MAC MPN)(MF SPC)
(N)	E. coli 5 144 552	8	8	8	8	6	$1.0x10^{10}$	$6.8x10^{10}$	$4.5x10^{10}$	$7.4x10^{10}$	$9.1x10^{10}$	6.86	4,33	(MPN EMB MF) (EMB MF SPC)(MAC)
(O)	K. pneumoniae 1 215 773	8	8	8	8	8	$2.0x10^{11}$	$1.7x10^{11}$	$1.5x10^{11}$	$1.6x10^{11}$	$1.7x10^{11}$	1.24	4,35	(MPN SPC EMB MF MAC)
(P)	C. freundii 1 404 573	8	8	8	8	7	$7.3x10^{10}$	$9.2x10^{10}$	$8.7x10^{10}$	$8.7x10^{10}$	$9.8x10^{10}$	0.81	4,34	(EMB SPC MF MAC MPN)

Table 11. "Frequency of occurrence" of experimental variables presented in Tables 9A-9P and 10.

	HIGHEST	SECOND	THIRD	FOURTH	LOWEST	TOTAL	DEGREE OF FREEDOM	CHI-SQUARE
MPN	11	0	3	0	2	16	K-1=4	25.88
SPC	1	5	3	4	3	16	K-1=4	2.75
MAC	0	2	4	1	9	16	K-1=4	15.88
MF	0	6	3	7	0	16	K-1=4	13.88
EMB	4	3	3	4	2	16	K-1=4	0.88
TOTAL	16	16	16	16	16	80		

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